ROADS AND RAILS

AND

THEIR SEQUENCES, PHYSICAL AND MORAL.

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LONDON:

CHAPMAN AND HALL, 193, PICCADILLY.

1862.

TO THE READER.

My reason for publishing this volume is, the belief that I *know*, and have something to say, which I have endeavoured to put in plain language. Years back, conversing with one of our highest philosophers, he remarked, "When the student and the practical man come to the same conclusion on any subject, the conclusion will probably be the right one, being arrived at by different methods."

My schools have been, years of travel, studying Nature, as well as Man and his Works, and years of practical utility in Engineering, planning the construction of nearly all machines that run on roads and rails—and the roads and rails also—from a navvy's barrow

up to a locomotive engine; constantly striving with more or less success at the improvement of most things connected with transit or movement, whether by traction or propulsion; seeking in theory for true principles, but not taking any new theory for granted till verified by practical results; recognising also the fact that every great result must have as a basis a sound theory or scheme, and that at the basis of every scheme put in practice is the chief agent—Man—and therefore, man himself, and how to morally use him, so as to derive from him the greatest amount of utility, cannot be omitted in the calculation.

W. BRIDGES ADAMS.

Hampstead, London, June, 1862.

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ROADS AND RAILS.

CHAPTER I.

THE PHILOSOPHY OF ROADS.

RAILWAYS AND HIGH CIVILISATION—MAN WITHOUT MEANS OF TRANSIT—MAN WITH TRANSIT—THE WATER ROAD—DIVISION OF LABOUR AND CHANGE OF LABOUR.

When the writer first began to consider the question of Roads and Rails, his thoughts took the direction of structure and defects; but it soon appeared that the roads themselves were but a small part of the question; they were only means to an end. After all be done that can be done in the way of improvement, after cheapening structure and lessening working expenditure, the question of the universal applicability of the latest forms of roads—the railways—has to be considered: their enormous effect in saving human labour, their

applicability to cheapen human food and to add to human happiness. As thought goes on their universality becomes more and more apparent; there seems scarcely a human operation that can advantageously exist in future without them.

It seems almost a truism to state that the word "Railway" is really only a convertible term for human progress in high civilisation. Without *roads* either by land or water the human beings of the world would be little else than families or tribes dwelling in a state of ignorance of all but that which immediately surrounded them. Exceptional philosophers there would be, as ever have been, but the fruits of their philosophy would not be wide spread. The philosopher, or lover of wisdom, would have but small scope for the exercise of wisdom in its true meaning, *i.e.* the Lordship over Knowledge. Men of powerful judgment and capacity have existed in all ages, as strong of brain in the world's infancy as now, as capable of ruling, possessing the dominion, or *dom*, but lacking the knowledge, or *wis*, in any extended sense. And we can conceive that the child of a Shakspeare, or a Bacon, or a Humboldt, placed in infancy on a coral island in a re-

mote sea, with nothing to gaze on but the blue central lagoon, the cocoa palm, and the tribe of black men around him, would have but little knowledge to rule over, little beyond imagination whereon to exercise his thoughts. He would waste his power upon the desert. Intensity of unsatisfied longing would prey upon him, and in the absence of excitement he might become a savage tyrant, a dominator over souls and bodies, for want of an external world to conquer, for want of knowledge to satisfy his cravings and powers of combination. He would eat his heart out, like Napoleon in St. Helena, for want of *work* to do.

But let a ship appear and carry him afar, to the wide domain of hoarded knowledge, his strength of mind would exercise dominion over that knowledge as his legitimate vocation, so soon as he had mastered the alphabet and language wherein men converse. The reading, the writing, the signs of quantity are his tools wherewith to work, and he comes to be the poet, or the statesman, or the military leader, or the engineer, or the dominator over matter, of the nation or town in which he dwells, according to the bent of his mind, or the circumstances of the time or

people. His "knowledge" is not his *power*—that phrase is but a hackneyed fallacy in its common acceptation, for many there be with ample knowledge to whom power is utterly lacking. The "King of Men" is he who can guide or rule them for the time being, he whom they spontaneously elect as their leader, according to the qualities or perceptions that are in themselves. But the *knowledge* is the tool of the *power*, without which the power cannot work. And he who, with a mind born to rule over other men, possesses the greatest amount of the knowledge which the majority hold in respect—the majority of power, not the mere numerical majority—will be ever the ruling man of his time. It is for this reason that men possessing what is called abstract knowledge do not thrive in a worldly sense. They are in advance of their time, and it must ever be so, for men cannot appreciate the value, even in a worldly sense, of that which they do not themselves *know*. Therefore a Dalton may starve in his laboratory while the purveyor of the sybarite may revel in his own or in other men's luxuries. And the philosophic discoverer of the laws of light must turn spectacle-maker ere the world can see his value. As philosophical men

are rarely practical business men, and cannot put into matter that which they possess in mind, they serve chiefly as a kind of milch cow for another species of men, who reap the worldly profit by possessing that peculiar knowledge and acuteness in which the original-minded men are lacking. And each has his reward after his kind. The tastes and habits of the thorough practical man are usually of the more expensive kind. The thoughtful man is simpler in his tastes. But it were a part of wisdom, even in a worldly point of view, that the world should take care of its abstract benefactors, lest, abstracting wholly *from* them and giving nothing *to* them in return, the race should die out and leave us a nation of Chinese, reproducing eternally and originating nothing.

What circumstance is it that has constituted the wide distinction between the savage youth of the coral island and the man he becomes in the nation or town? The circumstance that has changed him is the road—the watery highway, and the vehicle of transport thereon—the ship. The river, the sea, the ocean were the earliest roads of mankind; and on their borders is found the commencement of civilisation. The sea-coasts of Greece

that gave a water way to the Norse coursers of the Vikings, probably helped to plant there a new and mingled race of men so marvellous in their attributes, as compared with the common men of the time, that they came to be regarded as the "seed of gods;" yet, probably, a race who, if we could look on face to face as they then were, would be found to differ little from the race of Englishmen who now go about the earth working marvels in material progress that future times will regard as mythic. The Argo of old Greece was not more marvellous than the icebound ships of Franklin. The Golden Fleece of Jason was a small thing compared with the Californian fleece that the English race has torn with as much rudeness from a Mexican race strongly resembling modern Greeks in all but their sailor qualities.

All these things were done by virtue of the water road, for in the early times as now, the sea may be said to unite rather than to separate distant regions. The interior of large districts has ever been the abode of barbarism, and the march of civilisation has been along the course of the military roads. The Romans were the greatest power of the old world; and the Romans were the greatest road-makers. The

military roads of the Scottish Highlands terminated fruitless rebellions, but the mineral roads of modern times have done more to civilise mankind than the military roads of Napoleon.

The efforts of the printing-press in civilisation cannot be estimated too highly, but yet there is no doubt that speech between man and man does more than print. The preacher does more than the printer. Could men of genius multiply their thoughts to numbers by the aid of speech widely as by print, marvellous would be the result. The human emotions of the sympathetic speaker mingling with the intellectual powers of the brain strike in corresponding sympathies on his audience, and permanent effect remains. The vibration of the voice on the nerves of the ear is more powerful than the effect of letters on the eye. Speech is more than writing, as music is more than speech. Between writers speaking different languages the commerce of the press is very limited. The few, and not the many, are the reapers in these fields. But the same peoples brought face to face engender between them a new language, a *lingua franca*, which, freely translated, means speech of the free, and this tends to the prevention of quarrels

between them. Variety of speech and dialect between provincials of the same nation, is a frequent cause of quarrel all over the world. The republic of letters is ever cosmopolitan, but in a narrow circle. The republic of roads will be world-wide.

Thirty years back we were accustomed to boast that we possessed the finest roads in the world. Probably they were so of their class, for Macadam had brought his system to perfection, making an irregular mosaic work of the surface. But for whom were these roads made? For a comparatively few of the wealthy classes, or for the couriers of commerce—the riders or commercial travellers. The sphere of the humanising influence was limited merely to adjoining towns and villages. A journey of fifty miles was a question of a week's wages to a labouring man. Under such circumstances people did not travel save for business, and their places of birth were denoted by the manner of their speech. The time is recollected when Stepney, and Poplar, and Blackwall, were a kind of no man's land to those dwelling near the Minster of the "far west;" when bulls were baited in Tothill-fields; when to have been to Gravesend and returned safely invested

a labouring Londoner with something of the attributes of a traveller, in those days when omnibuses were not, in this land of Cockayne.

All this is changed, but the change is as nothing to the change which has to come, when railways shall have attained their full development. What the highway was to the river and canal before steam existed, that has the railway become to the highway—a better road. But it would be a mistake to suppose that railways have culminated either in capacity or structure The railway in its perfection, complete in all parts, has yet to be invented. Why else the complaint of shareholders that maintenance of way costs up to 300*l.* per mile per annum. Gladly would they say, *Divide et impera*—"Make a good dividend and rule over us"—to any railway chieftain who would stay this evil.

One great advantage resulting from the spread of railways is the great stimulation of the observant faculties through the community which has access to them. They are educating large numbers in progressive industrial art, and tending to break up a large social evil. Adam Smith taught long ago that the division of labour was a most important

element of production on the large scale, but he did not dwell upon the other truth, that it tended to generate an enormous amount of individual helplessness. Factory workers doing one thing only, become parts of a large working machine, and if any accident happens to any part of the machine their work stops, and they become paupers, because they can do no other kind of work. The processes which drive children into schools, or shoals to form men and women into classes and grades, are not wholly beneficial, but sometimes detrimental to humanity. Men and women who understand but one thing, be it shirt-making, or nail-making, or wheeling a barrow, are in the condition of the Irish people when they depended wholly on potatoes, and it is not desirable that dread of a "cotton dearth," should hang over us like an incubus. Throughout the world the worst paid people are the followers of a single technicality, unless that technicality be of a rare speciality. Division of labour might be a very useful thing in the origin of manufactories of mere handicraftry; but it has grown up into a division of labourers into classes, of Trades Unions, of Glasgow Thugs, of Sheffield Guy Fawkes's—the "Ratteners"—of deterioration of intellect,

of gluts and scarcities of human machines applicable to but one kind of work, of dull droning, of alcoholic excitement, sensual wallowing, and occasional appalling starvation.

The writer, some years back, in New York, paid some attention to the conditions of immigrants. The mayor of the city was the recipient of the tax on emigrants, provided for cases of destitution, and the distributor of relief. One day a poor Englishwoman, just landed, applied for help and work. The magistrate asked her many questions as to the kind of work he had at his disposal, but at the mention of every various employment her answer was in the negative—she could not do it. At last the mayor bethought himself to ask her what she could do, and the affirmative answer came: "Pack files!" She was a Sheffield woman, and could do no other earthly thing but that. Neither make nor mend her clothes, nor cook her food. As files in New York only require to be unpacked, her case was hopeless till she had learned a new trade. Division of labour in her case was certainly not wholly a good.

With the advent of machinery this division of labour, praised by Adam Smith, has grown to be a fruitful source of pauperism. It is as

fearful a thing to depend on one kind of labour as to depend on one kind of food. In numerous trades a few hours a day serve to master the needful dexterity, and when the work is too long continued it becomes painful drudgery, the division becomes less profitable, and it were better to change it for some analogous employment of a less irksome kind. Mere change of employment is rest to many men. Mere class men and women are not profitable to a nation, and the habit of changing their employment is probably the chief reason why the people of the United States excel English labourers in shrewdness. Farm men, and factory men, and mechanical men dwelling near together and capable of changing to each others' employment, would not be poor or helpless. Their faculties would quicken by variety, and their labours of loathing would become labours of love. Henceforward the motto of the educators, of those who would destroy feuds amongst workmen, who would eradicate evil passions and destroy Trades Union selfishness, should be the "Change of Labour," substituting it for Division of Labour. The negro field labourer rests himself by going to a dance; the sempster who pursues his avocation in a

sitting posture, rests himself by standing upright.

It is only by cheap and convenient transit facilitating the aggregation of persons and things, and their dispersion, that this desirable change can be brought about. And in all those processes which are mere monotonous repetitions, there is the precise class of labour which can be, and should be, almost wholly performed by machinery.

CHAPTER II.

ENGINEERING.

WAY OR ROAD—NARROW AND BROAD TRACK—FRENCH MALLE POSTE—RAILWAYS A GROWTH OF SUCCESSIVE CONTRIVANCES—STEAM LOCOMOTIVE ORIGINATING ON COMMON ROADS—MURDOCH, TREVETHICK, CUGNOT, BLENKINSOP, THOMAS GRAY, GEORGE STEPHENSON—WHAT IS ENGINEERING?—MILLWRIGHTS—BRINDLEY—MODERN ENGINEERS—PRACTICAL MECHANICS THE BASIS OF ENGINEERING—DISTINCTION BETWEEN CIVIL AND MECHANICAL ENGINEERING—CONTRACT SYSTEM.

A WAY or road for wheels to run on may be made in many modes, but a road is good in proportion to the evenness, smoothness, durability, and general level of its surface, offering the fewest obstacles to the wheels, and the smallest amount of retardation by gravity. The broader the road the more costly it becomes, in proportion to its quality, if labour is bestowed upon it; and if perfection is to be approached, it becomes essential to confine the wheels to a narrow track and concentrate upon that the cost of the inferior broad road. In

this particular, our modern railways are the antithesis of the "green lanes" of the olden times, and the military roads of the First French Empire were made on a similar principle, a narrow central portion being paved with large squared stones, and the sides left in the natural condition of the ground. A durable road was thus obtained, but so rough of surface as to damage the vehicles and goods, and annoy passengers. Whoso has travelled in the "leathern convenience," not unaptly called the Malle poste, and been jerked all ways till his ribs were bruised and his skin excoriated, has learned to execrate such roads, albeit works of so-called art. He will prefer the old ruts of the soft ground.

We are apt to regard our modern railways as an invention produced by one individual mind. It is almost considered a heresy to doubt it. But nothing is more certain than that the railway, as we at present possess it, is a compound of successive contrivances by many individual men. It did not start like Pallas Athene, fully armed from the head of Jupiter. It was a process precisely akin to that of a traveller patching from time to time the soles of his shoes as they wear by the roughness of the road. It was a necessary

growth of the digging and transportation of minerals, coal and metallic ores to furnaces and seaports. When the pack-saddle was set aside, and wheels adopted, it was not long before impassable ruts were formed, and were filled in from time to time with any material that lay most convenient, brushwood or stones; and planks, such as navvies use to this day for their barrows, were still more convenient. As the waggons were apt to run off the planks at curves, it became necessary to border them with rising edges to keep the wheels in track And then came the difficulty of the wear of the planks beneath the wheels. To prevent this wear they were ultimately treated like the wheels themselves—covered with strakes of iron. This led the way to the tramways of iron, a hard narrow trammelled surface, not permitting great speed on account of the breakage of the cast-iron, and ultimately both cast-iron wheels and cast-iron trams were contrived to suit each other. We hear of them first about the year 1630, constructed of timber, and in 1760 both rails and wheels were made of iron where work was hard.

The steam locomotive—the essential of our modern railway locomotion—had its birth on the common road; brought forth from the

brains of Murdoch and Trevethick, in England, though brains both in Switzerland and France had seethed at the same work, and the Lorrainer, Cugnot, is the first on record stated to have made a practical machine, albeit one that would not work. Blenkinsop, one of our northern men, in 1811, made practical locomotives to haul coal up steep ascents, by means of a rack attached to one rail, with a toothed propelling-wheel working into it, and thus securing adhesion. And it was subsequently found that the adhesion of plain wheels was quite sufficient with moderate ascents. The tooth and rack system was thus lost sight of, though no doubt available for many useful purposes, and some day to be revived with more perfect structure.

So iron rails and wheels and locomotive engines had, by the working of many brains and consecutive contrivances, been made practical facts, and in the year 1814 George Stephenson made an improved locomotive engine with more contrivances added to it. In the year 1820, an enthusiastic man, named Thomas Gray, wrote pamphlets advocating the extension of steam railroads all over England, to the exclusion of horse draught, but it was a feature of his plan to use rack and tooth for

the purpose of adhesion. This arrangement would of course enable comparatively light engines to develop the whole of their power advantageously, but it would be with a large sacrifice of speed.

In the year 1830, all the world was astonished at the steam speed gained on the opening of the Liverpool and Manchester line; all but the few who looked beneath the surface and knew that there was nothing to be astonished at in the mechanical conditions; that it was a result of simply grouping together existing practical knowledge. The real matter to be astonished at was far other than mechanical. Invention was but a small part of it. The mass of the community beheld the aggregation of contrivances which had been silently going on, for the first time, and seemingly suddenly, grouped together in a mass, and the result was hailed as a new and complete invention, and from that time to this railways and engineering progress are considered by the majority of persons in this our England to be synonymous terms; because a man with a will and a purpose, trained in the miscellaneous practicalities of coal-mining, and possessed of good common sense, free, more-

over, from all official or educational trammels, and with the engineering world still in its infancy as to transit, and none of the high official stools occupied, and without any capital but his brains—practical but not very imaginative, and with great power of concentration—did gather together existing facts, and, with the aid of other contrivances, combine them into a whole more or less harmonious, with a result that struck dumb with admiration the mass of non-thinkers, who beheld, for the first time, a fire-horse whirling at a speed of thirty miles per hour over the quaking bog of the Chat Moss—the fire-kelpie and the water-kelpie in linked alliance to do man's work, by practically diminishing time and space, making cotton-receiving Liverpool a suburb of cotton-using Manchester. There was, absolutely, no marvel at all to the thinker, as regarded the mechanism. The thing worthy of admiration was the persistent energy of that coal-bred man, who forced all the circumstances into contact; who, strong in his own belief, worked on silently till he had inoculated a sufficient number of other men with his own belief, and achieved fame and fortune by being the first adventurer on ground not before turned to

use. This could not be done twice on the same track.

This man was not an engineer in the modern sense of the term; he was an outsider, scoffed at by the profession, and till the last, when death closed all scores, he was not admitted as a member of the institution, the largest amount of whose professional work he had called into being. He might have become an associate, but there would have been something ludicrous in George Stephenson, the founder of railways as now used, being made a disciple, and full membership amongst civil engineers was not awarded to the man who had worked and achieved in contravention of all rules: so he founded an Institution of Mechanical Engineers at Birmingham.

What is engineering? Sixty years back the word was hardly known, save in connexion with the army. The men who did the work of construction, now called engineering, were then called millwrights—men with brains and hands, who wrought their appointed work without the aid of machine tools—men who directed and worked with the labourers who helped them. They were "Masters" in the true sense of the term. It was the self-acting steam-engine that first set the fashion of steam-

moved tools, and gave rise to the term engineering. In this sense engineering may be a matter of the veriest routine or red tape, and a mechanical engineer may be a mere ironmonger, dealing in engines, lathes, screwing machines, and other tackle, just as the "domestic engineer" deals in ranges, stove-grates, pokers, shovels, tongs, and fenders. And the railway engineer may be a mechanical ironmonger, minus the practical skill and plus the road surveying. These qualities belong to the contracting tribes who now make railways on stereotyped plans at schedule prices, and as like one another as cheeses or tubs of butter.

It has been stated that Brindley, the great canal-maker in England, was the first to call himself a civil engineer, and the term is now used very much in the mode in which "barrister" is used. Brindley was an original-minded man, who did a great and original work; and there are many barristers on record who have been great lawyers; but the term barrister now, is simply a certificate of a certain number of attendances at dinner, as the term civil engineer may frequently only mean that the bearer has smoked a very large number of cigars in a drawing-office.

But some other qualities, quite distinct from these, are required in what is now called a successful engineer, *i.e.* the accumulator of a large fortune by large railway or other works, for the world measures success by the amount of money, representing power, or supposed to represent it. The successful railway engineer of the present day must assist in the first place in the getting together and outlay of large sums of money, or he can have no scope for profit. Therefore, he must be essentially a man of business, that one quality without which success cannot be achieved. He should be a good surveyor—not necessarily a land-measurer—but a man with eyesight and insight to select the most convenient route mechanically and commercially; for even the bird on the wing does not make a direct line between two points, but allows for the wind. He should be a good mechanic—not necessarily a maker of machines or moulder of materials—but a good judge of what is sound or unsound in principle. He should also be a good organiser of men—not mere rank and file—but a skilful selector of the officers who have to do his work. He should, in short, possess the qualities of a general, *i.e.* supposing his business to be to make railways at the lowest economical

cost, with a view to the greatest service to the public, and profit to the shareholders. If his business be simply to make as many railways as possible in which the shareholders are the last persons considered, and the chief object is profit to the promoters and contractors, all the qualities required by the so-called engineer are those of a man of business. All the rest he can hire, good or bad as may be, and it would excite some surprise were shareholders to be brought occasionally face to face with the inept men who really decide upon questions vital to profit or safety. Their skill is upon a par with that of the building tribes, who erect houses like packs of cards in the environs of large towns, all on the same pattern, for the purpose of sale, and without the slightest regard to their serving the real purpose of dwellings. It is not to be supposed that the majority of engineers are men of this inferior calibre, and it is quite certain that a good man of business with the judgment to surround himself with really efficient men, would be a better conductor of railways than a mere machanician without the worldly qualification of the business faculty.

But the basis of all civil engineering is practical mechanics, and it was the knowledge of the

practical mechanics of coal transit, added to his strength of will, that gave George Stephenson his foot-hold, and enabled him to do things in advance of professional men. In most professions which have attained a status a society grows up, and it is remarkable how quickly each society seeks to stereotype practice, and to stop progress. At an early period of civil engineering a society was formed in a certain nameless country, and mechanical engineers of eminence were invited to belong to it. At no long period after the formation of the society, the civil engineers combined together to exclude the mechanical engineers from full membership, and to confine them to the position of associates. They considered them to be a species of upper-class tradesmen, and not men of science, and only important by reason of the magnitude of their business. After hearing the proposition, a consulting engineer of the highest faculties rose up and remarked:

"Very well, gentlemen, then I will send in my resignation accordingly."

"You, Mr. ——, what for? You are a civil engineer."

"Certainly not," was his reply. "I am a mechanical engineer, and never signed myself

C.E. in my life. I presume that if Mr. Watt were now alive you would refuse him also admission?"

"No such thing, Mr. ——; we should, of course, be proud of such men."

"Yet he was a mechanical engineer!"

"Oh! ah! true; but—he was a successful inventor, and made money!"

"Yes, exactly. And inventors should never be recognised till they are successful?"

"Quite so; and we admit nothing to be discussed that is not strictly practical."

"Then, gentlemen," replied Mr. ——, "try your experiment, and I will predict the result. The mechanical engineers are your main stay, for all civil engineering is based on mechanics. Make your body exclusive, and the mechanical men who secede will become your rivals. It may possibly take them three months to master that portion of knowledge which constitutes civil engineering, but how many years will it take you to master the mechanics of the question? Don't mistake your vocation, which is to get the ear of the public and spend their money, and in the process, while dealing with fixed matter—as earthworks, stations, platforms, and goods-sheds—you dictate to your clerks; but when

it becomes a question of moving machinery, you turn it over bodily to the mechanical men, who, whatever their short-comings, know more about it than you do."

The reasoning of the man who *knew*, prevailed over the men who did not know, and so the mechanical men remained.

When George Stephenson constructed the Liverpool and Manchester line, he did it to the best of his ability, according to the existing state of knowledge. He knew nothing of the contracting process, whereby an engineer in the present day is enabled to hire a contractor to find brains as well as materials and labour. Men were put to work at day-work, after the old fashion, and George Stephenson and those he employed—master and men—had to find brains and hands amongst them, and a great deal was done by "rule of thumb." The practices of the coal lines were imported to the Liverpool and Manchester. Stone-block sleepers with cast-iron chairs and wrought-iron rails were laid on the levels and cuttings as "permanent way," and cross timbers were laid on embankments where the stone would not lie, and the line over the Chat Moss had to be floated on the bog by inprovised methods, the chief test of engineering ability; meeting

the difficulties by original mother wit, corrected by practice and experience.

On this line a shrewd man of business, hight Joseph Locke, digested subsequently the practical details into the system of specific contracts, since so largely carried out on railways. He had not all the mother wit of George Stephenson, but he had his own business tact, which he verified on the Grand Junction. He made a cheap line by adapting engines to steeper gradients, and gained a reputation which secured him a fortune.

Whether the contract system is for the advantage of railway companies or not, is still a problem. There is no doubt, now that contractors are thick upon the ground, that it ensures competition, and induces the lowest apparent cost, but whether it is really the cheapest, having reference to the quality of work, is very doubtful. Contractors work by means of inspecting engineers, whom they employ to buy material and supervise labour. If companies execute their own work, they also employ engineers to supervise labour and materials. But they must also employ the same engineers to supervise the contractors, and therefore they practically employ two sets of engineers. Now, there

seems no reason why the company should not buy materials and labour at as cheap a rate as the contractors do, and therefore they ought to execute their work more cheaply, doing it themselves. Why, then, can the contractors work cheaper? They do not, but they employ servants with their interest in the work, bent upon saving by every means in their power, both in materials and labour; and companies' servants, as a rule, are underpaid, and feel little interest in the matter, even though no work passes muster which is not in accordance with the spirit of specifications. There is another reason. Directors have a very natural desire not to exceed estimated costs, which are the consideration for shareholders embarking in a line; and to do their own work to estimate, requires close watching and a good amount of contractor's knowledge. And it is easier for the engineer to let work in large contracts than in small ones, and of course that lessens the amount of competition; but so long as the estimates are not exceeded all parties are content, and the shareholder also if he gets his five per cent.; but this is not for the advantage of the public, who have to pay more money for travelling, and ultimately try to cut down fares by getting another and

a rival line, not always remedying the evil, because after long fighting they are apt to coalesce. A worse evil of the contract system is, that it tends to prevent all improvements which interfere with an established price list, and may give trouble in preparing a new one.

Of the extra cost of railways caused by law and parliamentary expenses it is hardly worth while to speak. They are a consequence, as in all public improvements, of being made in a thickly-peopled country, where every kind of material, land inclusive, has obtained an enormously increased value, and where established technicalities have outgrown common sense, and each is largely paid for what Mr. Carlisle calls "tongue fence."

CHAPTER III.

THE ACTS OF GEORGE STEPHENSON.

SWEAT OF FACE, AND SWEAT OF BRAIN, AND ITS RESULTS ON MAN'S WELFARE—GEORGE STEPHENSON—PHYSICAL CHARACTERISTICS—BOYHOOD—GENERAL APTITUDE AT WORK—RISE IN LIFE AND WAGES—MARRIAGE—WIDOWHOOD—DRAWN FOR THE MILITIA—PILE OF HOARDED GUINEAS — TAKING CONTRACTS — CLOCK-MENDER — CUTTER OUT OF GARMENTS — CLEARING OUT THE WATER FROM KILLINGWORTH HIGH PIT—THE FIRST ONE HUNDRED A YEAR—THE LOCOMOTIVE—FIRE-DAMP IN THE MINE—SAFETY-LAMP—WHAT IS SCIENCE?—PATENTS—INVENTORS AND CONTRIVERS—WALTER HANCOCK—LIVERPOOL AND MANCHESTER—HOUSE OF COMMONS—RAILWAY JOCKEYING—MAKING THE RAILWAY—LOCOMOTIVE COMPLETED—MANCHESTER ROCKET—SUBSEQUENT IMPROVEMENTS — A SELF-TESTIMONIAL MAKER THWARTED—SUN'S RAYS AND COAL.

"In the sweat of thy face shalt thou eat bread," was the primal curse laid on our progenitor, and many were the ages that elapsed ere his descendants discovered that they had been endowed with faculties under which that curse was destined ultimately to melt away and be no more. For the sweat of the brow

was gradually substituted the sweat of the brain behind the "portals of the head," and from that sweat came forth marvels, as much marvels in their infancy in the early ages of the world, as they are, now that they are in their full blow and development. Whether typical, as Tubal Cain or as Vulcan in the Mosaic and Greek dispensation, they who mastered the secrets of fire and water became the great prophets of our human future. The moving power of the universe, heat—heat, that circulates in man's arteries and veins—heat, that lifts the water to the mountain summit and pours it down in rivers—heat, that converts the atmosphere into winds, and drives ships over the ocean—heat, that shakes whole continents, and causes the solid land to quake—heat, that wraps the welkin in a flame of sheeted fire — heat, that conveys man's thoughts round the globe—heat, that is the life of all living things, and which transforms inert gravity into a moving power—heat, converted into the slave of man's will by the energy of his brain, is the power appointed by Providence to enable him to win the world from the wilderness, and by the extinction of drudgery to give him time for the study and enjoyment of all that is true and beautiful;

not the leisure of the sensualist, but of the high human being created by God in his own image. This world was given to us as a dwelling-place to have dominion over, and, as before the Creator all men are equal, it follows that so long as some are made to grind at the mill that others only may eat white wheaten bread, and that some are made to spin and weave that others only may be clothed in purple and fine linen, man's ultimate destiny is not worked out. Meat, clothing, fuel, and shelter—an abundance for all—are necessary for the development of man's best nature, and so long as these are in scarcity, so long should the energies of man be bent on their supply, and not till that be achieved should the desires of mere luxury be supplied. Though this truth be not clearly perceived, there is an instinct in most men that prompts them to its fulfilment as surely as the beaver builds and the bee stores up honey.

Man must work: for the health of his own body and soul he must do this, but the work should not be debasing. Where skill of mind is needed, there is man's fitting employment developed, through his body. Where mechanical operations only are needed, there machines should be used, and not moved by

the heat-power resident in man's body. The process of mere earth moving by human hands is simply a process for converting man into a fuel-consuming engine—the fuel being beef and bread, and the work done a proportionate result of the mass of fuel he is able to consume or digest without injury to his living machinery. Not for this was man created throughout the ages, but for other and higher uses. His meat, clothing, fuel, and shelter, will ultimately be provided and developed by far other means than the present, the drudgery gradually disappearing in constantly refining processes of man's brain, opening through the ages with increasing purpose. The heart swells with the glowing, gushing pulses that the imagination of these things engenders.

The workers of the world are its benefactors, especially those who labour to diminish the drudgery of others. Amongst the processes of civilisation, not the least important is that of easy transit. In proportion as a man can travel, his means of instruction increase. Small are his means who, having to live by daily work, must depend on his own limbs alone for transit. Blessed was the first horse-tamer, blessed the first framer of a river raft, the

digger-out of a canoe—converting the moving force of nature to the transit of man.

The life of one of these workers who has stamped with his character man's latest phase of transit has now been some time before the public—edition piling on edition—an unmistakable testimony of the interest the public takes instinctively in those who have served their fellows faithfully. The man who efficiently yoked fire in harness and drove the iron steed over the quaking surface of the Chat Moss, was no common man. The fire-kelpie and the water-kelpie he alike held in the hollow of his hand. He saddled them and bridled them, and bound them down as the slaves of man's will—slaves all as potent and as marvellous as the Jinné of Eastern fable. In future ages, he, too, may become a myth, if by chance every copy of every edition now pored over by thousands should be destroyed and only the tradition be left. Yncas Manco Capac, the civiliser of Peru, was, according to some, an Englishman, or Yengueeseman, with a name lost in strange speech. Some equally strange name may become the traditionyme for George Stephenson. But we, in our time, must know and appreciate the manhood that was in him.

There stands his portrait, fronting the title-page of Mr. Smiles's work, the very man as he lived in his latter days—a keen-eyed large-browed Viking, with firm-set lips, indicative of a resolute will—as though he had just concluded a sentence in his deep northern guttural accent; a leader of men in mine and quarry, through mist and fire-damp, with the old Danish blood in his veins, which, had he lived eight hundred centuries earlier, might, with his strong competitive spirit have led him to vie with the deeds of Ragnar Lodbrog, in a long galley under the Raven Standard. The garb of modern respectability is on him, the habiliments of broad-cloth and muslin, but the *man* is above all; and there is no mistaking the staple of English manhood, that could look into the future, and bear down present opposition, as he did the bullying of Ned Nelson, the fighting pitman of Black Callerton, in his early career.

The boy was industrious and loved gain—fair honest gain—the result of industry, from his first employment of cowkeeper on the Way leaves, at twopence per day; and he loved bird-nesting and whistle-making, and clay-modelling, and toy-mills, on the gills and becks of Dowley Burn. And then he could

plough and hoe turnips at fourpence per day, and pick stones out of the coals at sixpence per day, and drive the gin-horse at eightpence per day. Withal he loved birds, and, above all, robins and blackbirds, and taught them to live tame with him; and he bred rabbits, and competed with his neighbour stock-owners, ere the days of the Smithfield Club Cattle Show. And he grew to be an engine-fireman at a shilling a day; and he could swing the hammer, and put the stone, and lift four hundred weight; and at seventeen years of age became engine-driver and plugman, in full control of a steam-engine and pumps to keep the mines free of water, when, with a rise of wages to twelve shillings a week he exclaimed, "I am now a made man for life." By Thor and Odin, and all the gods of his ancestors, this was a lad of mettle. Olaf of Norway, with spear and arrow, and skates to boot, could not sum up a list of more manly accomplishments. And he learned reading, writing, and arithmetic at the minimum and maximum charges of threepence and fourpence per week, holding to his own manners instead of those "taught gratis." And he had a dog who was his servant, and carried him his daily dinner through daily perils

from other dogs. And at twenty years of age he became a breaksman with seventeen and sixpence to twenty shillings per week; and, proud of his office as any of his ancestors would have been as helmsman to the Black Raven, and he won his appointment against all opposition by hard work and resolution; and he wooed and won his Fanny Henderson, and rode off with her seated on his pillion behind him, full fifteen miles, on his wedding-day trip to his own home, as gallantly as any Lochinvar over the border. And to win her he had striven hard to earn a competence. He learned to mend and make shoes, overtime, for his fellow workmen, for gain, and he new-soled the shoes of his Fanny for love, and he carried them in his pocket all Sunday afternoon, as a knight might carry his lady's scarf. Sweet was the first golden guinea saved from his labour, nucleus of the plenishing of his home, and—more than Ragnar Lodbrog could boast of—was the "good legible round-hand wherein he signed the registry of his marriage." And when his "bower" was burned out and his clock stopped, he learned to make it go again, and to mend all his neighbours' clocks, and added to his income; and on the 16th December, 1803, not the least memorable

circumstance of his life took place, for on that day was born his only son Robert, whose life has yet to be written, and is to be done to order.

A brave man this—one of our English worthies; a man of sterling energy, failing in nothing he undertook, saving only perpetual motion, a thing belonging to the Creator, and not to be imitated by art. And so he went to Killingworth Colliery, and settled there as a breaksman, and there by close study he acquired the knowledge that forced his employers to promote him for the sake of their own interests.

The boy was born and christened, but the man underwent the heaviest loss that humanity—true humanity—can sustain. The wife of his bosom was taken from him by death—the grim exaction of tribute from the happy—and his boy was put to the nurture of a kindly neighbour. In mental pain he resolved to travel, and took suit and service with the colliery owners of Montrose, to erect a Boulton and Watt steam-pumper and lifter. On foot he crossed the border, and in twelve months saved 28*l.*, with which he returned on foot to his boy and his poor blind father—blinded in the service of that very steam on

which the son was destined to spring to eminence. A very pious Æneas he proved, carrying his sire from Jolly's Close to the West-Moor of Killingworth, paying out of hard earnings and savings 15*l.* of the old man's debts. A brave man this, of will and purpose, though with a wounded heart, and stricken with the loss of a sympathising wife. Pleasant is the picture of the boy Robert riding to the old man's cottage on a primitive ass, and he, like Esau's father, guiding his hands over child-bearer and child, in fault of eyes, and bestowing his blessing on his winsome lad.

Not yet were George Stephenson's trials ended. He was drawn for the militia, and the brain and arm written down in the registry of Nature for the regeneration of human transit, were by man's blundering contrivances determined to no more fitting employment than the shouldering of "Brown Bess." But he knew better; he knew himself to be of the leader class in civil rather than in military engineering, and he paid away his pile of hoarded golden guineas to be left alone to fulfil his conscious natural aptitude. He, too, was amongst the number of those who looked to Young America as the true home of industry; but the sweeping away of his earnings also served to prevent

his emigration from the greater country to the lesser one, wherein man grows to a less vigorous growth and perfection, and where fifty years are as the three score and ten of England.

In 1808 he appears to have taken his first contract as one of three breaksmen, finding their own oil and tallow, no doubt speculating on many a thrifty saving; but withal that, averaging only eighteen to twenty shillings per week.

Robert, too, "for school, was fit," and how to find the means? Clocks and watches still wanted mending, and shoes were still to be made and soled. And there was also a touch of the artist—the utilitarian artist—in this man of ours. He set up tailor, not the thing of threads and stitches of our modern days, but a veritable *tailleur*, a studier of man's form and stature, and a cutter-out of artificial integuments for him to a fitting pattern, which "ilka gudewife might stitch together her ain gate," and the clothes found fame as "Geordie Steven's" cut. Hear this, ye artists! who pass your time in dressing up lay-figures for painting, in garments made by a "tailor good lord!"

Verily, true engineering is a many-sided thing. It scorns nothing as too great or too small. It is the conversion of matter to men's

uses by processes of what is called art, but which really is nature, for its source is in the brain that God created. Nor is there really any distinction between mechanical and civil engineering. They are merely gradations. Many were the days that elapsed from the inauguration of the first wooden needle to the bright glittering tiny thing of polished steel that knew no rest in the hands of the shirt-makers, who earned sixpence per day under the modern Mosaic dispensation; a veritable metallic bar so light that it can almost float in water, and yet is a cone and a cylinder and a portion of a sphere, and has two channeled excavations and an elongated perforation, and is so rounded in the "eye," that the thinnest thread is uncut by the tensile strain of drawing together woven fabrics; and marvellous as this is, what a stride was it found when a variety of this needle was taken and made the tool of a machine that might be worked by the hand of a blind man or by steam, and never torture the eyesight of man or woman worker. How much greater a stride shall it be when the same machine shall be almost extinguished, and made useless by the steam working machine, that will give forth, not broadcloth and calico in flat webs, but the very gar-

ments themselves, flowing robes, or succinct tunics, for the philosopher and for the athlete, for man and woman and child, stamping a costume, graceful as ever dreamed of by the poets and artists of elder Greece, and withering up the uncouth monstrosities engendered by idle wantonness. This, too, is engineering, more original than the imagination of a crude sea-monster—an imperfect compilation of form and matter and machines; the creation of a Frankenstein rather than of perfected art; the incarnation of "bigness,"—bigness without completeness; bigness to astonish rather than to fulfil; bigness to consume much material, like the idol Bel, to consume much meat, bigness to set the ironmasters' craving, but not fulfilling all the conditions required by those "who go down to the sea in ships." Verily and in truth, there is engineering in earnest and engineering in sport, or for profit, like the prestidigitation of a gambler, in which the artist is overwhelmed by the necessity of conforming to the success of the money speculation.

None of this was in our faithful honest worker, George. He did that which was in him, and next him with all his might, and more than all, through every kind of obstacle

he knew and could seek out his real work. Engineering is truly every kind of operation that tends to lessen human drudgery, and no one knew it better than he. Mechanical work is that which is stationary, and not progressive. The master minds o'erleap the obstacles to progress by the insight that is in them, and their patient diligence and untiring industry in working step by step, as the sailors say, "hold on and belay." From cutting-out clothing for miners, to planning and working the steam-engines, through which alone they could continue their workings, nothing came amiss to our hero.

In the year 1810, when Robert Stephenson was seven years old, the turning point came in the career of his father. The Killingworth High Pit was clean drowned in water. An atmospheric engine had been at work for twelve weary months, eating up coal, and croaking and whirring and drawing water, but after the fashion of the pitchers of the Danaides, for it ran in as fast as it ran out. It was a mass of water running upwards unceasingly but unavailingly by means of heat. All the pump-doctors in the neighbourhood had tried their hands at it fruitlessly; but George, with his usual insight, had watched the engine when

it was first put down and marked the defects, and in his own mind had long before prescribed the remedy. And so one day of the most hopeless ones, Kit Hippel said to Geordie, "Weel, and what dun ye mak o' her." Geordie replied, like a master in his art, "In a week's time from this I could send ye to the bottom."

Straightway Ralph Dods, the head miner, an honest, kindly, fair-dealing man, though probably not exactly a born Baresark, with all the secrets of water open to him by instinct—Ralph Dods was told of it; off he went without loss of time and foregathered with George in his Sunday suit going to the Methodist preachings, Saturday at e'en: "Can you make the engine right?" "I think I can." "To work then at once." A right kind of man this Ralph Dod's.

But our Geordie had all the practical knowledge and experience of a born leader of men. His ocean-roving ancestors ever selected their own crews, and so thought he, "they must be all Whigs or all Tories." The Tories were doubtless the regular engineers or millwrights, bred to the craft, and Geordie was an interloper, not to be endured by the conservators of the mine. But knowledge was the means for power to work, and Geordie chose his own

crew, and in a week the mine was dry—clean pumped out—and honest Ralph gave ten pounds to the rising man of mark: "the biggest sum he had ever earned in one lump." This achievement was followed by the erection of a small engine at another mine, to accomplish by constant working steam-power that which an uncertain windmill failed in.

He had turned the corner in his career, he was a leader and not led. In 1812 he was appointed enginewright to the Killingworth Colliery, at a salary of 100*l.* per annum, with horse to ride and time to spare in trying all kinds of experiments, with one John Wigham, a farmer's son; and his son Robert, then ten years of age, was sent to "Bruce's academy at Newcastle," entering on the march of respectability and abandoning the parish clerk and primer. Amongst his other qualities, Geordie was something of a trader. He bought and sold guineas, "fair fa' their honest sonsie faces," and turned 100*l.* into 120*l.* He had saved his first 100*l.*, and this, to a man born and bred as he was, was not the mere money value, but the representative of qualities of a higher kind that enabled him to do it. And there was no pride about him; he lived in the one-roomed cottage with a bed

in the "riggin," and built an oven with his own hands, and added rooms as wanted till it became a four-roomed cottage, and he grew to have the control over all the machinery of the allied collieries—this self-taught, but not overweening man. His thoughts were ahead of his time, he saw the progress of the future, but nevertheless worked steadily at the passing while it lasted, and educated his son by his own intuitive methods so as better to turn to account and digest any cram that he might have got at school. And they read books together, he and his son and John Wigham, books carried by the boy Robert on loan from Newcastle. And thus in the brain of that blind man's son was gradually stored up the practical knowledge that was to win for him fame and means by the process of enriching his native land.

Somewhere about the year 1780, so runs the tale, a travelling millwright—in those days the kings of mechanics—footsore and with the broadest northern Doric accent, stopped at Soho, a locality once indicative of field sports, but then the engine factory of Boulton and Watt, and asked for work. His aspect was little better than one of "beggary and poor looks," and Mr. Boulton had bidden him

God speed to some other workshop, when as he was turning away sorrowfully, Mr. Boulton suddenly called him back:

"What kind of hat's yon ye have on your head, my man?"

"It's just timmer, sir."

"Timber, my man, let's look at it. Where did you get it?"

"I just made it, sir, my ainsel'!"

"How did you make it?"

"I just turned it in the lathie."

"But it's oval, man! and a lathe turns things round!"

"Aweel! I just gar'd the lathie gang anither gate to please me. I'd a long journey afore me, an' I thocht I'd have a hat to keep out water; and I hadna muckle siller to spare, and I just made ane."

By his inborn mechanism the man had invented the oval lathe and made his hat, and the hat made his fortune. Mr. Boulton was not the man to lose so valuable a helper, at least in those days, when good men were scarce, and so the after famous William Murdoch took suit and service under Boulton and Watt, and in 1784 made the first wheel vehicle impelled by steam in this England of ours —made it with the very hands and brain-cun-

ning that had before produced the "timmer hat." Out of that seed, after seventy-three years of sowing and reaping its produce, a goodly crop has sprung up, that, like the grain of mustard-seed, replenishes the civilised earth, and will yet civilise the uncivilised.

And so Trevethick, neither more nor less than a captain of a Cornish tin-mine, yet no less a leader of men, and men, too, of the kind who never follow a sham leader; this Trevethick, bred to the arts of fire and water by old William Murdoch, found a cousin, one Andrew Vivian, a miner, who had saved enough coin to pay the State the price of a patent—a heavy tax on rising ingenuity—and joined with him to build a steam-carriage, in 1802, to run on the strange tracks then called roads ere the days of Macadam. And he taught steam a new tactic. Till then steam had driven the piston only in one direction, the vacuum caused by a large tank of water giving the reverse movement. Trevethick made steam drive the piston both ways; the condensing tank was got rid of, lightness was attained, and locomotion became practicable as soon as a fitting road could be attained.

In 1804, with marvellous progress, Trevethick married a locomotive to the Merthyr

Tydvil Railway, after vainly trying to make his first machine work on the mud, at the locality whence now depart innumerable trains —the Euston station. In 1812 he constructed another engine for Mr. Blackett of Wylam, the colliery owner, which was turned into an iron-founder's tool; and then another, the far-famed "Black Billy;" and then he bade adieu to steam locomotion, to unite his time and energies upon the silver mines of tricky Peruvian owners. He who was upon the eve of stirring the civilised world to its centre had he persevered at home, was doomed to years of squabble with half savages in a then almost unknown region.

Mr. Blackett was a man of purpose, and solved the problem of the adhesion of iron wheels on iron rails without the use of cogs, and thus took away a huge fallacy from before men's eyes. There was found to be adhesion enough for moderate inclines.

And now George Stephenson comes upon the course. He knew instinctively, by the strength that was in him, that he could make a better engine than "Black Billy." He took up the locomotive where Trevethick left it, and he was not daunted by the locomotive of Murray of Leeds. In the year 1813 he gained

the consent of Lord Ravensworth, a descendant of the Liddels of the "Bateable Bit," well knowing how to guide the money-gear as ever a red-handed forbear to guide sword and spear; and this Lord Ravensworth had the insight to know a veritable man when he got hold of him, and he stinted not the good red gold which, in the hand of George Stephenson, was to raise up a beneficent demon to do men's work. He believed in the self-taught, and he trusted him. And so, in 1814, with one John Thirlwall, the colliery blacksmith, a name also from the "Bateable Bit"—with John Thirlwall for his foreman, head man, and best workman, our self-taught man turned out his first engine, the first made with smooth tired wheels, and verified the judgment of the Border lord by drawing up a slight ascent thirty tons load at four miles per hour. And in 1815 he built another engine. Patient and diligent observation, and industry with untiring energy, enabled this self-taught man to do what other self-taught men had failed in, and also men taught by others, if such a thing can be. In truth, we labour under a great fallacy in supposing that any human being can teach any other human being anything. He can but

put him in the way of observing, and, if he have that faculty also, of absorbing.

A faculty of absorbing had this man of ours. For thirty years lay in him the memory of his first fire-damp explosion, till he told it out to a Committee of the House of Commons in June, 1835; and such a narrative as Defoe could have told of the Fire or the Plague of London, a piece of mind-picturing after spontaneous nature and not after practised art. We see the thing as we read of it, and well we know how much more we should have seen it had we heard the tale told. It was a volcano with a clear shaft instead of a crater. "Wood and stones and trusses of hay were blown up into the air like balloons." And with a lesser explosion a living man was thrown up and landed without injury. And from time to time he witnessed more of these incidents, till at last he grew to look on them in philosophical speculation, just as the elder Pliny looked down Vesuvius, and at last once too often.

But not so our hero. One day, in the year 1814, there rushed a man in hot haste to his cottage with a startling tale that there was "fire in the hold," the deepest main of the mine. Had it been a ship with fire in the

hold there would have been less marvel that a descendant of the Vikings should breast it—fight it—when with no power of escape; but here was our man safe upon deck—a land deck—wide enough to flee away and be at rest in safety. But not so he! His crew were in the hold, and their wives and children were screaming in wild despair. Down into that pit of darkness he went—down into very Hades; the creaking rope and lowering corve making hoarse music to mingle with the cries and supplications arising from the imperilled men below. Down he went, and sprang from the corve, the king and master of the fire-damp, the lord of the fire-kelpie. "Stand back, my men! and now the boldest six amongst ye follow me!" And then and there, with trowel and spade, instead of sword and spear, stronger to save than his ancestral Norsemen to slaughter, his six men followed him at his bidding with bricks and mortar instead of powder and ball, and then and there was a wall built up such as brave working men can build, and the fire knew its master. No deed of derring-do on wall, trench, or mine military, was ever more heroic than this of our self-taught man. The galleries of mines military are not filled with fire-damp, nor are there vertical shafts of

deep descents into the very jaws of Nox and Erebus.

But not heroism alone was the question. How to work in safety amidst surrounding peril was the problem to solve, and so George Stephenson set himself to work to build a perforated wall round his lantern, through which light might flow but could not fire, so that he might grin in the foul fiend's face, and bid him avaunt. Like Franklin with the atmosphere, he would play with the mine lightning and remain unhurt. He made a lamp, which he believed would be safe, and he ventured into the gas of the pit with his lamp in his hand, leading the hope which was not forlorn, while Nicholas Wood and John Moodie, the viewers, stood aloof. How he worked to perfect his lamp, nothing daunted by constant trials and the absence of the scientific knowledge that forced him to grope in the dark, and get painfully to his practical knowledge and achieve it, while Davy, at a later period, arrived at it by an easier process—is it not written, and well written, too, by his biographer?

This man of ours could think and work, but he could not write in print, and was slow of speech; yet, when he had found fame, he

was required to exhibit himself and lamp at the Philosophical and Literary Society of Newcastle, and so Nicholas Wood—one who has written a book, and a good book, on railways, embodying all George Stephenson's doings therein—Nicholas Wood went with him to do the speeching. But Nicholas Wood had not thought over nor made the lamp. It was not of him, in him, a part of him, and, teased with questions, he could not always give a correct answer; and then our George, with the Berserker rage strong on him, pushed aside the spokesman as he stood behind him, and, like the chief and leader that he was, with all the "burr" of Newcastle and Berwick combined in his throat, made clear by strength of lungs and demonstration of hands what he wanted in words, and he was thus a more popular lecturer than the veriest word-monger that ever stepped on platform. The "Geordie" lamp became a true Aladdin's lamp to all those northern gnomes, and the other went to Davy and the lecture-halls. The coal-winner in Nature's own laboratory had won Nature's secrets as truly as the great chemist in his artificial laboratory.

Science! How much of true quackery is wrapped up in that word, that cheat for the

vulgar ear, which deludes the mass into the belief that the scientific man is necessarily a gifted man, whereas the mere scientific man is very commonly only a mere repertory, a mere barren list and catalogue of things that have been found out by others without science—a chest of tools without the knowedge how to turn them to account. Schemers, inventors, discovererers, and chance-medley men of all sorts, bring forth a heap of facts; the man of science classifies them, and writes a book about them, and forthwith he is generally regarded as though he had discovered them all; and withal he may be lacking in the judgment needed to apply them in any new combination for a useful purpose. The world and its uses and capabilities were all created before the mathematicians wrote their books; and, with all possible respect for exactness, we may yet assume that an orange is a greater thing than a geometrical description thereof, and the first practical locomotive a greater thing than the mathematical calculations afterwards made on it.

But the writer desires not to be misunderstood. Science is knowledge, and theories may be made from it; but the Newtons come few and far between who can construct a true theory. The empiric who

constructs by accident is less than he who constructs by design and forethought, and the discoverer by forethought is greater than the cataloguer who comes after him, and, making a list of the facts, calls that science which is not knowledge or insight. The "men of science," so called, are rarely synthesists. Were the synthesists also masters of all accumulated knowledge, what a wondrous stride would the world take! But Providence works by its own methods, and the faculties of men are distributed amongst different individuals. Many are the schoolmen who can talk learnedly of all the "mechanical powers" and the properties of atoms, but where amongst them is the synthesist who can combine them into a locomotive out of his own brains?

In his practical experience of railways and locomotives, George Stephenson had discovered that rail and wheel were mutually dependent on each other; and so, after long thought, he determined to take a patent, which he did in conjunction with William Losh, ironmaster—and probably moneyed man—in 1816, and for a very comprehensive system, viz., "the construction of the engine, carriages, carriage-wheels, railways, and tramways employed for that purpose." In modern times we should

have entitled it, briefly but comprehensively, "Improvements in Railways, and in Engines and Carriages to run thereon," *i. e.* ere what is facetiously called the "Patent Law Amendment Act" was passed, which was called a boon to inventors. What sort of a boon it has been we will briefly inquire.

Under the old law an inventor paid about 110*l.* for a patent for England, some 80*l.* for Scotland, and about 150*l.* for Ireland, the dear one being usually of little value, and commonly only taken to prevent a piratically-disposed rival from setting up as manufacturer there, merely to avoid the English patent. But, for many things, neither Irish nor Scotch were of any value, especially when "England and Wales, and our town of Berwick-upon-Tweed," and the British colonies, formed the only useful boundary. A railway is, in truth, part and parcel of the machines that run on it, and England is the chief seat of the manufacture of "rolling stock" and fixed plant. A patent, therefore, for England, for improvements in railways, and in engines and carriages to run thereon, was practically all that the inventor required; and this patent cost 110*l.*, with such further cost for specification and drawings as the lack of writing, or drawing power, or of

time rendered needful for the inventor to employ in outlay. And, moreover, he was not confined to railways only, in his title: he might add thereto any improvements he might have discovered in other constructions. This 110*l.* fee was said to be, and no doubt was, an oppressive tax to a poor inventor with one idea; and just prior to the Great Exhibition an agitation was made to reform it, and the price of a patent taken for England, Scotland, and Ireland, was reduced to about 25*l.*, getting on to 40*l.* and 50*l.*, in the case of a poor man not competent to draw up and furnish his own specification. This was, doubtless, a boon to the poor man of one idea, and very objectionable to the rich patentee, who had no desire to see patents much more accessible.

But there was another distinction. The 110*l.* under the old law for England, or the 340*l.* for the three kingdoms, secured the full enjoyment of the patent for fourteen years. The patent under the new law is for three years only. If prolonged to seven years it becomes 75*l.*, or for fourteen years, 175*l.* Thus the man content with the English patent has now to pay 175*l.* at three periods, instead of 110*l.* at the outset—a very heavy rate of interest.

But there is more behind. Inventors are of two classes—contrivers with one idea and inventors proper, with a true cycle of ideas based upon principles, to which latter class, as well as the former, George Stephenson belonged. Contrivers are they who, finding a defect in some existing thing, devise a remedy more or less useful, but who never would have foreseen the defect had not practice pointed it out. The men of philosophical brains, such as can take in the cycle of construction in transit, and are competent to deal with it in all its phases, they are inventors proper, looking far into the future, and foreseeing with a prophetic view their scheme, in most of, or all, its details.

To make a railway—and put it to use perfectly—involves a large amount of details. Culverts, drains, cuttings, embankments, bridges of brick, timber, stone, cast-iron, wrought-iron, above and below the railway, ballast, sleepers, rails, chains and fastenings, points and crossings, switches and turn-tables, weighing-cranes, lifting-cranes, water-tanks, and station buildings of many kinds, iron roofs and wooden roofs, and platforms, and ticket-printing arrangements.

Then follows the locomotive, compounded

of the steam-generator or boiler; the engine proper, compounded of cylinders, pistons, and gearing, leading, trailing, and driving-wheels, framing, bearings, suspending springs, traction and collision springs, and so on; water-heating apparatus, smoke-consuming plans, and tender for fuel and water; post-offices, carriages, lined and stuffed for the wealthy, made uncomfortable for the less rich, and often unbearable for the poor; trucks, horse-boxes, goods-waggons, powder-waggons, coal-waggons, coke-waggons, timber-waggons, ballast-waggons, with wheels, axles, axle-boxes, axle-guards, buffing and bearing springs, tractive apparatus, framings, and coverings.

Then come workshops for the repairs of engines and carriages, and engines with lathes, planing-machines, drilling and slotting-machines, hydrostatic presses, and machines of many other kinds. When we consider that a bad road is capable of destroying the rolling stock, and *vice versâ*, it becomes evident that a master-mind is needed to harmonise these things.

But let this first-class inventor present himself at the Patent-office for his protection "for his improvements in railways, and in engines and carriages to run thereon," he

will be informed that he must divide his plan into as many patents as he has of new features or particulars. Permanent way locomotive engines, carriages and waggons, wheels and axles, axle-boxes, springs, water-cranes, water-tanks, coke-ovens, bridges and roofs, and a separate patent for stationary and other engines, and another if there be anything new in his steam-generator, unless he gives up to others, gratis, the applicability of his new plans to "like purposes." Thus, he will have to take eleven or twelve patents, being 300*l.* for three years, 900*l.* for seven years, and 2100*l.* for his full term of fourteen years; which, under the old law, he might have obtained for 110*l.* for England, and 340*l.* for the three kingdoms. Verily, the position of the first-class inventor, who may be a poor man, as well as may be the simple contriver, has not been bettered. The boon or boons are purely imaginary. "It is all 'tother."

But this is not all. A new planet making its appearance on the inventive horizon is immediately followed by a host of satellites generated by the "contrivers." The invention is pirated on all hands, and the only remedy of the inventor is, first, an application or applications in Chancery for an injunction or in-

junctions, and then permission to try his right and establish the validity of his invention in a court of law, to which he and his opponents have to summon half the leading men, in the profession to which his invention belongs, as witnesses, with a cloud of black gowns splitting hairs and words, and bent, not upon truth, but upon law-logic. A fortune may be consumed in this process, and the more certainly if the opponents bind themselves into a company and club purses against the individual—no uncommon case. Then, unless he possess rhetoric and power to enlist friends in his favour, or induce capitalists to join him for the sake of the lion's share, his chance is hopeless. As it was in the beginning it is now—the longest purse takes the place of the longest sword, and the banded company grins scornfully in conscious power; but we trust this shall not be for ever.

There is a remedy when the Legislature shall will to take it up. The inventive class pay special taxes, leaving a surplus of some score of thousands per annum. Here, then, are the means of building a Patent-office and Gallery of Inventions such as a great nation should possess, illustrated with a library and model chamber: Here, also, are the means to endow a Court of Judges and officers in the

midst of all the evidence required, in which justice could be done to the inventor and upon the oppressor, without cost to the general community, and a huge scandal got rid of from amongst us. But this is a question to be more largely entered upon at another time.

And so George Stephenson obtained his patent for his first locomotive, and built one which worked till lately, or still works on the Killingworth Colliery Railway. And after that he thought of taking up the subject for common roads, but his usual cautious bits of experiment satisfied him that it was a wasteful expenditure of steam-power to work upon a yielding and uneven road—that steam was not intended to be a gravel grinder. Many men, and practical men too, preached to the contrary, and there is no doubt that their efforts to work out the fallacy of imagining that steam could work more cheaply on Macadam than on iron, did—like the search of the alchemists after the philosopher's stone—accomplish important results. No locomotive for railways yet constructed combines the lightness and power which was obtained in some of those road machines, and from which, even yet, something might be learned. No more earnest worker at locomotion was

found—not even George Stephenson himself—than Walter Hancock, one of a family in whom invention is instinctive and seemingly hereditary, and one of whom has essayed to make a steam-engine with india-rubber cloth coated over with an armour of chain mail.

Nor was Walter Hancock in pursuit of a fallacy altogether. He recognised the fact that iron made a better road than Macadam, but to make such roads required the outlay of millions for lands and Acts of Parliament, and buildings and machinery. Even to lay iron rails on common roads was costly; and of this there was little hope. So, like the man he was, he set to work to make the best of an existing road, where houses, and buildings, and water, and fuel might all be obtained without outlay other than that of the locomotive machine. He knew the road to be inferior, but he preferred to make the machine to suit it, not as the best possible road, but as a useful one, and capable of being made more useful by substituting steam for horses.

And so he went about his "little-go" as bravely as George Stephenson about his "great-go."

"Heating-surface" rightly used, is, in jockey phrase, the "bread-basket" of the locomotive,

and this honest Walter perceived. Well does the writer recollect the square canister-looking boiler which Walter brought to John Farey, that veritable judge of inventions, who yet lives in the memories of all capable of reverentially appreciating him. It was a nest of water diaphragms, composed of iron plates, covered with bulbous-looking swellings pressing on each other, counteracting strain and forming impinging surfaces for the flame. When this ultimately grew to the full size and was borne upon wheels, with pistons, cylinders, and gearing, the wood wheels, made after the best fashion of the then wheel-craft, continually broke down, till weary Walter set to work to scheme a new fashion of wheel for himself, in which, dispensing with the ugly wooden nave, a thing like a huge bung with a bundle of mopsticks stuck round it, he mitred his spokes together in radial lines and bolted them between central iron plates, like the steering-wheel of a ship, and no more of his wheels broke down after that.

But a cranked axle was used, taking at the same time the strain of the pistons and the weight of the machine, and this also was constantly breaking down. To meet this case the crank-axle was made into a separate shaft,

and the wheels, connected by a straight axle, were driven by chains round toothed wheels. These chains and teeth were incessantly breaking down, and after long suffering, patient Walter determined that it was impracticable to use the carriage out of a straight line, or turn corners with two wheels keyed fast on one shaft. And so he arranged his wheels to revolve on the shaft independently of each other, and with tackle to throw them in or out of gear at pleasure. Thenceforward his machine was practicable, though far from perfect, and he found that the adhesion of one wheel on the road was sufficient for the purposes of propulsion, save in the emergency of getting into a gully, when he was accustomed to connect both wheels and throw down a coal sack before them to obtain "bite." But to attempt to run at six miles an hour with both wheels connected, was not practicable. He established the fact that to minimise resistance, the wheels were required to be separate, and this fact has never yet been recognised on railroads, because of the facility for the wheels slipping on the iron rail either in the direction of the rail or transversely, or of equalising the movement by the variation of diameters of conical peripheries. In the latter case, slow

movement will permit that which is not practicable at high speeds, where the sledging action of one or both wheels has to compensate for the varying length of the two rails.

And Walter Hancock did for four months run a steam-omnibus between Paddington and the Bank, taking up and setting down passengers, and stopping and starting when required, like any horse-omnibus, and over or on literally a mud road, up and down Islington hill, if we recollect, an incline of one in twenty—and then he gave it up. Why?

For the same reason, to some extent, that a horse-omnibus would have been given up. He had but one solitary vehicle, and any need of repair threw him out of work. And he needed capital to build more, and to open water and fuel stations where steam ostlers might be in attendance, in lieu of the grinning men in sleeved waistcoats and highlows, who rejoiced at his mishaps, and would not have given him a pail of water to save his boiler from bursting. And then the road trustees abhorred him, for there were questions about tolls, and they "served him out" by burying him to the axles in loose road metal; and more than all, the Liverpool and Manchester rail was just then in its heyday, and the

capitalists all eschewed the idea of a common highway whereon the mortgagees could not get common interest.

But a change is coming on. Steam, which began its utilitarian career as water-pumper for miners, has long since become a farm-labourer. Portable engines, which some few years back counted by twos and threes, now count by thousands. Beginning by being merely portable, these farm-engines are now becoming locomotive, have learned to lay down their own rails, and, like tame elephants, they can disport themselves over ploughed fields and plough them, and climb over lumps and clods, pass over railway sleepers with the rails omitted, and drag cannon through morasses, and yet become ordinary engines when required to thrash corn, and pump water, and saw timber, and chop straw, and cut hay, and every kind of work that may be wanted, at the same time gradually converting mere clodhoppers into skilled mechanics.

Long it cannot be ere our suburban roads and our country roads will have iron rails inserted in their surfaces, over which locomotives with small wheels will work in hilly districts, and locomotives with larger wheels on more level

districts. George Stephenson was right in preferring iron to gravel for road surfaces; right in preferring levels to inclines; but, notwithstanding, it is good to have the iron surface to the inclined road where the traffic is small, till such time as the increased traffic will pay for levelling. The great trunk lines need feeders, and the branches of nature's trees are ever smaller than the trunks. When the time shall come that the roads leading to our farms and pastures shall be all iron lines, fuel and materials of all kinds will permeate the bye as well as the high roads, and a general mechanical education of the farm-labourers will raise them more in the scale, than the labourers of manufacturing towns. The squalid huts will pass away and be no more, the easy means of transit will unlock the latent faculties, and the labour both of townsmen and countrymen will be convertible to either locality. Steam has been hitherto a worker only for the general public, or for the purposes of production; but steam or some other form of heat has yet to be converted to all kinds of domestic purposes, whereby drudgery—the application of men and women to mere slave-labour—will become extinct.

George Stephenson took altogether six pa-

tents: one in 1815, for a locomotive-engine; one in 1816, for rails and wheels; one in 1822, for steam-engines; one in 1831, for wheels; and one in 1846, for a locomotive with three cylinders, having for its object the steadying of the engine under the alternate action of the pistons. Did these patents remunerate him for the outlay? Perhaps not directly; but at least they stamped the fact that he was the inventor, and not some unscrupulous rival without a conscience.

The character of the man was full formed and well known. He was appointed by Edward Pease and his directors engineer of the Stockton and Darlington Railway, at a salary of 300*l.* per annum. He now pursuaded his employers to change it from a horse to a locomotive line, and to lay down malleable instead of cast rails. In 1822 the first rail was laid, and in 1825 the line was opened for traffic. And meanwhile, a factory was established in Newcastle by Edward Pease and George Stephenson. A long-headed and far-seeing Quaker was Edward Pease, opening up the coal-cellars of nature to man's uses, far and near.

The Liverpool and Manchester Railway, the first locomotive line for passengers—first broached as a railway in 1821—was revived in

1824; and a pamphlet was published with George Stephenson's sanction, which drew forth a declaration from 150 merchants of Liverpool, calling for the execution of the line. A deputation was sent to Killingworth to examine the locomotives, and a company was formed to construct a double line. But another embassy was sent to Killingworth ere the preliminary survey was finally resolved on. And such a survey! Farmers, magistrates, and noble lords, in the deepest depths of igorance, opposing their own welfare. No doubt the survey was a series of trespasses, but the trespassers were willing to pay the fines and damages to gain their object, while the object of the opponents was, not damages but defeat. And so George Stephenson pitted himself against Lord Derby, and out-manœuvred him by bringing so large a *posse* on the ground that they could not be turned off, and so Lord Derby was left to sue for his damages. George Stephenson said he was under orders from his committee to execute the work, and like a good soldier of progress, he regarded nothing as impossible even under Lord Derby's ban. He worked by day when the watchers went to dinner, and by night at the risk of being shot for a poacher, and under threat of

being ducked, and being carried before the Worsley Dogberries. But he was not to be beaten; he—the Viking of the North—amid the more Southern tribes, who knew not of his arts and craft of fire, but only of water-craft, and so the opposing parties met in a Committee of the House of Commons on the 21st of March, 1824; George Stephenson on the one side—the new Columbus, the champion of the true and the possible—and black gowns and engineers innumerable on the other side, bent to deny the truth as earnestly as ever Spanish inquisitor did, for the lucre of present gain, and the defeat of future progress.

Have you, good reader of these sentences, ever watched a railway bill in a Committee of the House of Commons—one of these same railway bills—by advocating, or opposing, or omitting to oppose a given number of which, one Charles Austin, a barrister, accumulated thirty-six thousand pounds in one session of Parliament, exercising only "tongue power and palaver," useless to mankind in the main, while the original maker of the Liverpool and Manchester Railway only gained one thousand per annum for doing the world's work, and hard work too?

In this new St. Stephen's, called the Parlia-

ment House, the external form and figure of which indicates no master mind, no force of genius, but only plodding industry—a form like a carpenter's box, long and winged, and with projections at regular intervals, vertical and horizontal, called Gothic, because ornamented in the Gothic style, but which might be made Italian or Greek or Egyptian equally well if ornamented in those styles, or which might all be converted into a terrace of separate dwellings, with separate doors and separate knockers—in this new St. Stephen's, a museum, in which is collected internally the reproduction of all that was gorgeous in our ancestral buildings, improved by modern art, there is a long Gothic gallery of oak with a neutral-coloured wall on the one side, and endless western windows on the other; a recessed oaken ceiling, and an elastically wadded floor, from which footsteps give no sound. The hour strikes, and up the broad stairs pours a motley crowd of barristers in black bombazin and silken gowns and floured horse-hair wigs, the features eager and unscrupulous, showing much of cunning intellect, but little of moral worth; love of triumph, and carelessness of truth; engineers in broad cloth, black or brown, with hard material mathematical faces

—intellect, but rarely genius—bent upon victory as unscrupulously as the lawyers; solicitors, more sharp and shrewd in worldly knowledge than either of them; and their clerks, ready for any dirty work—not to be objected to, if only exciting enough, in hunting fellow-men; surveyors, red and rosy, in cutaway-coats of any colour, and trousers of impossible patterns, a sort of wild hunters, not pursuing game armed with guns, but pursuing levels armed with staves and theodolites; jolly men, inhaling deep draughts of fresh air from the preserves of Providence in the morning, rollicking as fox-hunters, and imbibing deep draughts of another kind in the evening; men, whose plotting is confined to the drawing-board and its tools, and who make up deftly rolls of paper that carry a railway through entire counties. Mixed with them are landed proprietors, bent on opposing till they get paid fourfold for their land, and obtain undertakings for bridges not required, but which they may afterwards commute for sums of money; stewards and bailiffs, and farmers and tenants, ready to swear anything at their masters' bidding; rival railway directors and secretaries, bent on making all new lines undergo what they have themselves

undergone in getting permission to be made, and making the poor silly sheep of shareholders on either side pay the costs; strangers of many kinds staring in surprise around them, and here and there quiet observant painters, or writers of novels, or a philosopher, studying the scenes from their various aspects. And amongst all the heterogeneous crowd, numerous exceptions to *genus* who have preserved their manhood and vitality independent of the calling in which accident, and not Providence, has placed them. Blessed core and kernel of humanity—blessed human heart that can make amends for all the evils that surround us!

Amongst the crowd may be seen strange people listening anxiously to the discourse of others, catching words here and there, and from time to time darting away; these are of the class called "stags," the demons of Capel-court, whose whole business is to buy and sell scrip shares, getting hold of them gratis at the outset, causing their reputation to be spread abroad, and then disposing of them at a premium—shares in possibly an impossible project, or one never to be made—the class of people who live upon the community without any apparent service to the community. Yet

let us not be too hard; all God's creatures are created for an end, even the stags of Capel-court. The work of the world is not all done by the virtuous. If it were proposed to a set of capitalists to make a line of one hundred miles, demonstrably a ten per cent. line, but that they should go without interest for four years, and not be permitted to sell a share till the completion of the line, it is doubtful if they would embark in it. But let it be understood that the shares, either incipient or complete, might be bought and sold and premiums gained thereon, the speculative spirit would be on the alert, the shares would be taken up, and the useful work would proceed, the stags being practically commercial agents in the matter. Not even stags are altogether vermin.

When the Liverpool and Manchester Bill first came before the House, in 1825, it was a contest for mercantile and manufacturing progress on the one side, and for game-preserving and stagnation, and the vested interests of canals on the other. The descendants of the Duke of Bridgwater, who made canals, through Brindley, amidst universal opposition —that Brindley, the untaught, who worked through primitive instincts, and, when asked

what Providence made rivers for, replied, with mother wit, "to feed canals,"—the descendants of the Duke of Bridgwater were as opposed to railways, which would pull down their water monopoly, as the carriers and packhorsemen before had been to the canals. It was certainly provoking when the water property had risen to an almost fabulous value—a real natural monopoly, for the canal men possessed all the water, and no one could make new rivers,—it was provoking that railways should come forth in which there could be no natural monopoly, but only monopoly by Act of Parliament, always capable of being set aside by some new Act of Parliament. In short, canals were limited, but railways were unlimited, so long as coal and iron might exist. All the regular-bred engineers, disliking the presumption of the untaught man in setting himself up to thrust aside their preconceived notions and formulæ, were enlisted as willing evidence on the part of the opposition; and George Stephenson alone, unaided, save by our old friend Nicholas Wood, and a mechanical engineer, a builder of steam-engines at Stourbridge,—one John Urpeth Rastrick, afterwards the maker of the "Brighton direct,"—had to enter upon the contest. The untaught man, with imper-

fect utterance, ignorant of the methods of schools, had to be baffled and browbeaten by a host of technical schoolmen and practical men, who had gone over and examined and measured at their leisure the course of the line, which he could only get at by glimpses. All sorts of evidence were brought forward—that the railway would stop the milk of the cows, the growth of grass, would poison the game, would burn down the farms, would frighten horses, would cost 270,000*l.* to get through four miles of Chat Moss, would be utterly unsuccessful, and yet would ruin the stage-coaches; and so, after a two months' contest of unscrupulous opposition, the bill was finally thrown out, though the preamble was passed. Canal-owners and land-owners were successful by reason of the impediments they had thrown in the way of the survey.

But the promoters of the bill were not daunted. Huskisson, afterwards the martyr to railway progress, and other members of parliament, urged them on. But, in deference to "the bubble reputation," the Messrs. Rennie were appointed the engineers to carry the bill through Parliament. The man who could make the railway could not talk sufficiently clearly about it. He was not school-

learned, but other-learned; not word-learned, but work-learned. The Marquis of Stafford joined the scheme as proprietor of 1000 shares. The inheritor of the Brindley canals became a partner with merchants and manufacturers; the monopoly was broken down, and the Act was finally passed, to the dissatisfaction of Lords Derby and Wilton, the strenuous opponents.

But now came the tug of war. The palaver was at an end, and the work had to be done, and so George Stephenson was appointed the working engineer at a salary of 1000*l.* per annum. He was the king of fire and water, and forthwith made his onslaught on that which most persons had pronounced to be impracticable—the Chat Moss, taking its name from a wild growth of underwood, fit for fuel.

The instinctive, untaught man reasoned: a ship floats on water and carries a load; *à fortiori*, a denser fluid than water will carry floating materials and a load equally well; and so he made a road of hurdles and heather, covered with earth to keep it steady, and when it showed a tendency to sink below the level, he loaded the moss beyond the track to balance it; and when the water oozed through, he invented a new kind of drain-pipe, formed

of waste tallow-casks, headed one into another, and when they were found too buoyant he ballasted them also to keep them down. But the surface of the moss was uneven, and a mile of low level had to be provided for by an embankment from the very bottom, which consumed so much material that the work seemed hopeless. This difficulty also was overcome.

To do this work the institution of railway navvies was first set going. The inland navigators, that is the canal excavators, were the nucleus which gathered aggregations from all England and Ireland, and wherever strong, vigorous men were to be found; but the staple of them, the pick and choice, were the men from Blackstone Edge, the growth of the mountain ridges of Lancashire and Yorkshire, with stomachs like ostriches, men of gizzards capable of cramming and digesting any amount of flesh-meat and bread, and turning it into bone and muscle to do any amount of work. "By faith shall ye remove a mountain," and many mountains were moved by the faith which railway shareholders had in each other, and the muscular giants they had at the control of their engineers. A veritable association were these navvies, and as much so as the Freemasons of old, who travelled about the

earth building churches, and palaces, and cathedrals. They were of the aristocracy of labour, that admitted amongst them no weakling, no ordinary mortal, but only he who could eat full rations, and do a full tariff of work. Truly a band of land sailors, earning their money like horses and spending it like children, ofttimes the victims of the tommy-shop, caring little for lodging, helping one another in distress to the sharing of the last shilling; imposed on by public-house keepers, and submitting to it, though knowing it, and with a peculiar custom of persecuting the cheating publican, by concealing from him that their contract was out on the line, and then eating and drinking his house empty and dry at a final feast, and clearing out without paying—a sort of balancing up of the general items of cheating they had suffered.

The tunnel through the sandstone rock under the town of Liverpool was not the least remarkable part of this undertaking, and herein a man of mark in railways made his grand stride. Joseph Locke was the second in command, who, amidst rushing water and blasting fire, drove this under-way through the solid rock, bringing all the craft of the northern coal-mines to bear on the longest and largest road

tunnel then known—a mile and a quarter in length. A self-taught man, also, who, by inward force, added language and power of expression to some mother-wit, a store of power to be used upon the Grand Junction, the South Western, and other lines in England and France, the after-growth springing from the seeds sown between Liverpool and Manchester.

Still remained open the question as to the haulings upon the line. Every one but George Stephenson and his son Robert, and his pupil, Joseph Locke, were against the locomotive. The directors, blindly groping, were not altogether satisfied to be directed by their self-taught engineer, and they procured a report from Mr. Walker, one practised in harbour work; and from Mr. Rastrick, one practised in stationary engines, recommending the stationary engine system of rope haulings in lengths of a mile and a half.

Upon this the blood of the Norseman was up again, and he called to him his young men, his alumni—Robert and Joseph—both afterwards civil engineers, and both of them members of parliament, and both since numbered with the dead—and then and there was the report of the wise men, Walker

and Rastrick, pulled to pieces, and the brains and pens of Joseph and Robert then and there demonstrated with the logic and the facts that were in them, and good king's English to boot, that the argument of the wise men was naught, and that the value of the new road must consist in the union of the locomotive with the rails. The directors were vanquished, if not convinced, and a reward of 500*l.* was offered, not to George Stephenson, but to all the world, for the production of the best locomotive engine, weighing six tons on six wheels, or four and a half tons on four wheels, with a pressure of 50 lbs. per square inch in the boiler, to draw after it twenty tons load, at not less than ten miles per hour.

The Killingworth engines weighed twelve tons, so something important had to be done to increase the power for the decreased weight. A long-headed man, one Henry Booth, the secretary of the line, propounded the plan of dividing the great bulk of the water in the boiler by a number of horizontal chimneys or small fire-tubes, thus increasing the heating surface. Mr. Seguin, of the St. Etienne Railway in France, claimed to have patented this plan in 1828; but Mr. Stephens, of Hoboken,

in the United States, claimed to have applied it to steamboats in 1807—the same shrewd Yankee who brought over to England, in the year 1851, a sailing yacht modelled on the lines familiar through long ages to Eastern pirates, and beat all the knowing ones accustomed to nothing but routine—beat them by a trick, as Lord George Bentinck beat the knowing ones of the race-course by putting his horse inside a carriage, and taking him what was supposed an incredible distance in a race against time.

The *principle* of the tubes to distribute heat and increase the heating surface is probably older than steam-engines. It is described in the old French cookery-books, where, in the *batterie de cuisine*, metallic tubes are to be provided to pass from side to side through large pieces of boiling beef, in order to convey the heat without boiling the outside to shreds. With this new idea, George Stephenson and his son Robert set to work to go in and win the 500*l.* premium against all the world.

On the 6th of October, 1829, the problem was to be solved whether a locomotive engine, weighing six tons as a maximum, could draw twenty tons' weight after it at a velocity of ten miles per hour.

Four iron horses came upon the ground—the "Novelty" of Braithwaite and Ericson, unpropitious name savouring of the transient rather than the permanent; the "Sanspareil" of Timothy Hackworth, which might have been called the *Mal*pareil, for it was like a haystack on wheels; the "Perseverance" of Mr. Burstall, too heavy to comply with the conditions of trial; and the "Rocket" of Robert Stephenson, giving evidence of the perceptive faculty of proportion, in the length, which gave it steadiness on the wheels—in the inclined position of the cylinders, departing half-way from their, till then, vertical position, and approaching the true position, the horizontal line—in the forward position of the drawing wheels, pulling the mass instead of pushing it—in the equalizing the load over all the four wheels by the projection of the trailing wheels astern—and in the twenty-five fire-tubes of three inches diameter, the very bowels of coke digestion.

The fire was lighted, the steam lifted the valves at the stipulated fifty pounds pressure, and the "Rocket" drew after it thirteen tons of wagons at an average speed of fifteen miles, and a maximum speed of twenty-nine miles per hour, one half more than the stipulation.

The deed was done—the speculation of the untaught man had become a fact. All the black gowns in England could not undo it, demonstrated they never so mathematically. A great and beneficial change was wrought for the world—a change of which, even yet, after the lapse of a quarter of a century, we cannot see the end; and old Isaac Cropper, a director, lifted up his hands, like St. Thomas, under conviction of error, and exclaimed with a loud voice, "Now is George Stephenson at last delivered."

The "Sanspareil" burst one of her cylinders. The "Novelty" failed in her wheels, which were of the Theodore Jones construction, loaded almost to breaking point with structural tension before the carrying load was put upon them; and the "Rocket" won the prize of 500*l.*, a fraction of the cost which English pluck and manhood had dared to venture for the magnificent ambition of achieving fame and fortune through services rendered to mankind, and the abrogation of all further cruelty to post-horses.

And now, how far did this engine fall short of what has been achieved up to the present date?

The boiler was for fifty pounds per inch, working pressure. Up to 1848, the pressures had risen to eighty pounds per inch. At that period engines had grown to weights impracticable for any rails to sustain with any durability. The engines slipped on the rails, from the simple fact that they deflected beneath the driving wheels; and the cry was for more power and weight, when in truth, what was wanted was better foothold, and vainly did Robert Stephenson and others point out that the roads were being destroyed with preposterous machines. In 1848 some few light engines were constructed, carrying their own water and fuel, upon four wheels, weighing not more than twelve tons, or three tons eleven cwt. more than the "Rocket" and its tender, and capable of taking fifty tons' load at thirty miles an hour, and with a lighter load travelling fifty miles an hour. But the pressure in the boiler was then first raised to one hundred and twenty pounds per inch. These engines, then, were to the ordinary engines as the race-horse is to the cart-horse—great elastic power was attained with light weight. In the one case we have eight tons nine cwt., with fifty pounds pressure; in the

other twelve tons with one hundred and twenty pounds pressure—more than double the power with little increase of weight.

The next point is the clothing all the heating surface in such mode that the heat may not radiate. The higher the pressure the greater is the radiation. The "Rocket" boiler and cylinders were all exposed; modern locomotives are clothed with felt and timber, and the cylinders are sometimes enclosed in the smoke-boxes. But they are not yet what they should be. Heat is the power, and all heat that escapes without doing duty is waste.

The "Rocket" was without the more modern contrivances for heating the feed-water, and for economising the steam, by cutting off the supply to the cylinders at any part of the stroke, and thus permitting it to expand elastically, to suit light or heavy loads or speeds.

Another modern improvement is, balancing the weight of the wheels and cranks, and the reciprocating parts also, so as to prevent the mischievous oscillation of the engine on the rails, and the consequent loss of power.

The wheels of the "Rocket" were, if we recollect rightly, of cast-iron with wrought tires. Modern wheels are made of forged

wrought-iron in one piece, and some of the tires are applied without the mischievous practice of piercing bolt-holes through their tread surface.

The cylinders of most modern engines are in a horizontal line with the driving axle, and light wrought-iron pistons in one piece are taking the place of the heavy compound pistons of former times.

The boilers of some modern engines are made of steel, which reduces their weight nearly one half; and it is probable that ere long steel only will be used in their construction, to the exclusion of iron.

Modern engines are made to consume raw coal, without smoke, instead of prepared coal or coke, with considerable economy in cost. But this is simply a result of the whole of the gases being thrown away in waste to produce the coke. It is very probable that neither the coal nor the coke is the most desirable fuel, a matter which has yet to be found out. Sulphureous coal is destructive to the heating-machine—hard coke to the working machinery also.

We find, then, that the *principles* which distinguish the modern locomotive from the "Rocket" are—the use of steam expansively,

clothing the heat-surfaces against radiation, heating the feed-water, balancing the moving parts, and coupling two pairs of driving-wheels together—a problematic advantage under the present arrangement.

The marvel, therefore, is not that some important points should have remained unnoticed, but that so many important things, should have been effected at so early a period.

And so the Manchester and Liverpool railway married itself to the locomotive, and the great untaught man became a practical power and authority. Many more lines did he set out, and one feature was to preserve, as far as possible, a dead level. Quite right in main lines of abundant traffic, but there is something also to be said on the other side. It is a question between annual cost of fuel and annual interest of money on capital. The dead level is the cheapest haulage, the steeper gradient is the smallest outlay. And it sometimes happens that the heavy loads are all in one direction, and the empty trains in the other. In such case it would be an advantage to have a constant descent in the direction of the load. And there is, to a certain extent, a similarity between horse traction and steam traction. It is well known that the most wearying road to

a horse is a dead level and straight line, even when bordered with trees as we have seen in France and Holland. It seems to break the horse's heart. A road of occasional rises and descents, and even of curves, suits him best, for he can ease his work and gather strength on the descent, changing the action of his muscles. And so a locomotive driver can choose his time when descending a gradient, to make up his fire without mischief from the lowering of his steam, and with the rapid movement down the incline, he blows up his fire to generate steam for the ascent.

There is another consideration in working railways not yet sufficiently attended to. The stopping-station should always be on a summit-level, whether natural or artificial, the main line being on the level and the station-siding turning out of it. To start a train into motion requires a considerably greater amount of power than to keep up the motion, and this power has to be absorbed in some mode before rest can be again attained. On the summit-level the train can be made to move down the incline with a less expenditure of power, and on arriving, the accumulated power could be absorbed in the ascent. For want of these arrangements, breaks are re-

sorted to, setting fast the wheels and grinding flat places on their surfaces, which act as sledge-hammers on the rails when put again into rapid movement.

The real life, the work of George Stephenson was practically ended when the Liverpool and Manchester was complete. He made other lines, but that was routine work; the trees of knowledge and experience had been plucked, and he came through the ordeal of business without blemish. He had a conscience, and did not advise the making lines for his own profit, without considering the probability of profit to the shareholders, who were to pay for them. He and his son Robert were appointed by Leopold of Belgium to survey and recommend the lines to be laid out, as railway lines should be done to some extent by Government, though not in all cases. And he went gratuitously to survey a line in the North of Spain for an English company, whom he recommended to decline it as not likely to pay. That same line is now under the auspices of Mr. Hudson, and has gradients of one in forty for a score and a half of miles in length. George Stephenson lived to witness the railway mania in 1845, but not to take a part in it, and he ulti-

mately retired to Tapton House, Chesterfield, to live out his days. Ere he retired one curious circumstance took place.

A railway speculator of great note and great deeds, lauded to the skies in his prosperity, and execrated beyond measure in his fall—one who filled the office of director, and contractor, and speculator, and railway gambler, or anything else that would turn a penny—rested one Sunday evening on his laurels in the North, in calm and placid contemplation of the deeds he had done, and the cash he had pocketed, and the aristocratic friends whom he, the *parvenu*, had laid under obligations to him; and thus he thought:—

"All sorts of men have testimonials given them, and why not I? It shall be so!" And so reaching to him pen and paper, he then and there drew up a handsome list of subscribers to the testimonial, with handsome sums opposite their names. Engineers and contractors of all kinds were made to figure therein. And when he had done he sent straightway for his humble friend, the secretary of his line, and also his private secretary, and asked him if there was any defect in the wording of the preamble, or any omissions in the list of names; and the secretary went over it, correcting grammar and

spelling, and finally approving of it, and then inquiring when the meeting was to be called. "Send it to the newspapers first," said the great man; "advertise it, and clinch the matter. Nobody dare refuse; and the subscriptions are to be paid into the bankers to my account, to make things pleasant."

And it was advertised, with the name of George Stephenson amongst the number. The paper fell into his hands, and in a towering passion, with all Berwick-upon-Tweed, and Newcastle to boot, foaming at his lips, he denounced the trick, and declared his intention of inserting his denial in the same paper. But he was overruled by a host of directors, who said his so doing would bring down the price of shares. But he said he would neither pay nor have his name to it, and it went on without him. The high "contracting" parties, the testimonialers, paid in their quota, and the testimonialee drew it out in good time, and bought a fine house with the money in the very midst of rank and fashion; and one of our pseudo high literary men was wont to contemplate him therein with stricken wonder and overpowering respect. The flunkey nature is not confined altogether to the middle classes.

So far have we followed our biographer's

record, a good book, which will yet go through more editions; for it treats of one of the subjects that enlist a nation's interest—the native-born men who help to make a nation great—men whose ancestry came hither as conquerors or as refugees, the best blood of their respective races boiling uppermost. The biographer has wrought at it as a labour of love, a service rendered to a chieftain of the body in which he himself has taken suit and service, and in which he himself ranks amongst the most eminent and most useful workers, a faithful and intelligent promoter of progress for the general benefit of the public.

And so our world-worker turned country gentleman at Tapton, and worked only at his own coal-mines and lime-kilns, and fed farming stock, and talked of "ousen, sheep, and kye," and the engineering of tillage and drainage, and how rain, percolating the soil, deposited heat therein. And he grew pines and melons, and bothered the crooked propensities of cucumbers by forcing them to grow straight in glass tubes; and his old tricks of boyhood came back, and he had dogs and horses and cows, and a new favourite breed of rabbits; and grew familiar with the birds and their nests; and he fattened coop chickens after a

new fashion; and he helped those who wanted help; and he read Coles on "Railways, Rheumatism, and Ruptures," and gave him his opinion on the former. And after a most useful life, passed in constant work for humanity, his death was hastened by the unhealthy atmosphere of his hot-house, and he died on the 11th of August, 1848, in his sixty-seventh year, not having reached the three-score and ten of English manhood.

In his chapter on character, his biographer, Mr. Smiles, has fairly described him; but, surely, it is hardly fair to Dr. Buckland, on Stephenson's visit to Sir Robert Peel, at Tamworth, in 1845, when Stephenson is described to have made the doctor acquainted, for the first time, with the fact that the sun's rays were remotely the cause of the locomotive's progress on the railway,—surely there is no need to quote the *National Review* for April, 1857, to prove this. George Stephenson is made to say to Dr. Buckland:

"Light is absorbed by plants and vegetables, being necessary for the condensation of carbon during the process of their growth—if it be not carbon in another form—and now, after being buried in the earth for long ages in fields of coal, that latent light is again brought

forth and liberated, made to work, as in that locomotion for great human purposes."

And Mr. Smiles remarks thereon:

"The idea was certainly a most striking and original one: like a flash of light it illuminated, in an instant, an entire field of science."

The idea must have occurred to many others before and since. We have now before us a volume of rhymes, published in 1831, by Effingham Wilson, from which we extract the following:

> "The means of our improvement have been fuel,
> Or organised combustion fixed in matter,
> Of various kinds, without which we should do ill,
> Though it is possible we may do better
> Than thus continue earth to disembowel,
> And o'er the surface her torn entrails scatter:
> Philosophy—'all vegetation' says—
> 'Is but a hoarding up of the sun's rays.'
>
> "Which, therefore, are the origin of 'Power.'
> Thick forests covered all the ancient earth
> Ere men dwelt on it; some convulsive hour
> Toppled them down in her unwieldy mirth,
> And subsequently laid them under cover,
> As a provision for her children's birth.
> So now we dig them out in shape of coal,
> Which drives our railway-engines to their goal.
>
> "'Increase of speed is loss of power'—so say
> Those who are of mechanic calculators,
> And so it proves. How many a bright sun's ray
> Must be consumed by our steam-generators,

Which travel on so many miles a day,
That speed in rays of light alone is greater.
Tell me how many ages it will take,
When coal is gone, another batch to bake?

. . . . .

"'Combustion's principle resides in water,
And, if we decompose it, hydrogen
Thus gathered may be used as burning matter,
To drive our merchant prows across the main.

. . . . .

the ever-flowing tide
Of godlike science, which incessant pants
After perfection, still to man denied,
Shall realise such things, the wildest gleams
Of fancy scarcely give in waking dreams.

. . . . .

"The ills that now beset poor human nature
Will all depart and leave it convalescent,
And the world's denizens will then exclaim,
'How strange our fathers failed to do the same!'"

The writer of these rhymes had clearly arrived in 1831—and, considering the slow process by which "small volumes of poetry" travel from the mind to the press, probably some years before—at the same originality as George Stephenson as to the past, and also at more speculation for the future. Could we hunt up the writings of early Greek sages, we should probably find the same ideas. The man who first burnt Athenian olive-oil to raise steam in the Œolipyle, most likely knew that the golden-coloured liquid was but dis-

tilled sun's rays, even like the golden oil of coal called paraffin—the liquid gas that now supplies the bright lamp before us, and makes us independent of those numerous gas companies bent upon hedging in the cuckoo of monopoly.

George Stephenson was a man of will and purpose, of clear perceptions, and of patient industry. Strong pugnacity, too, had he under opposition, or he could not have fought his way through the opposition; and, doubtless, the great injustice done to him, resulted occasionally in some injustice done by him to others, in strong prejudices and occasional obstinacies—the unamiable side of that quality which Fielding says the world calls obstinacy when unsuccessful, and resolution when successful; but, as George the Third said, when told General Wolfe was mad, "I wish he'd bite all my other generals," so are we glad to have many more such men. He was one of our native aristocracy, whom time and circumstances raised to leadership, to a Columbus fortune that can only occur at limited intervals. In our glorious old ballad of "Chevy Chase," our early king says:

> "We trust we have within our realm,
> Five hundred good as he."

So, also, we make no doubt that, in this our England in the modern day, we have many thousand such men, only lacking the opportunity to do man's work and God's behests in the same earnest mode as George Stephenson has done it, one name more added to the noble army of worthies, who beyond death's bourne dwell imperishably in the memories and traditions of their race.

CHAPTER IV.

PERMANENT WAY OF RAILWAYS.

FISH-BELLIED RAILS A MECHANICAL ERROR—PARALLEL RAILS—DOUBLE-HEADED RAILS—CAST CHAIRS—CROSS SLEEPERS—TEMPORARY RAILS—BALTIMORE AND OHIO—TIRE-BAR RAILS ON TIMBER LONGITUDINALS—AMERICAN AND ENGLISH LINES—BROAD AND NARROW GAUGE—IRISH GAUGES—SPANISH GAUGES—CONTRACTING SHARPNESS—NATURAL DATUM FOR RAILWAY GAUGE—PROPOSED MOTIVE FOR GREAT WESTERN GAUGE—STRUCTURE—GAUGE RIVALRY—FISH-JOINTS—WEIGHTS OF RAILS AND CHAIRS—CAUSES OF RAIL DESTRUCTION—DURABILITY SACRIFICED TO EASY REMOVAL—PRINCIPLES OF DURABILITY—ROUTINE—MATERIALS FOR SLEEPERS—TIMBER—METAL—QUESTION OF ELASTICITY—BALLAST.

The well-known circular of the Directors of the Liverpool and Manchester Line previous to working, prescribed a total weight of six tons to the engine, ten miles per hour speed, a steam-pressure of fifty pounds per inch, and a load of twenty tons including the tender, on a level railway.

The rails intended for such engines to run on were 50 lbs. per yard, and were made what is called fish-bellied, *i.e.* deeper vertically between the points of support than at those points over the sleepers. There was a false datum in this, in assuming the sleeper to be an immovable fulcrum instead of a yielding point, wherefore the rail ought to have been a parallel beam. This was found out in practice, and parallel rails were subsequently adopted. The rails were fixed in cast-iron chairs by an iron key, and the iron chair was fastened down to the stone block or wooden cross sleepers. It was found that the thin lower edge of the rail got damaged in the chairs, and Mr Locke devised the double-headed rail as a contrivance to answer two purposes—to afford a larger bearing in the chair and prevent crushing; and also to reverse the surfaces when worn. A wood key was used to fasten the rail in the chair.

This was undoubtedly the best form of rail devised, and while engines were not so heavy as to damage it, it was reversible. But modern weights of engines and the heavy anvils of chairs necessary to prevent breaking are found to crush this rail between them so as materially to interfere with its reversible quality. But

this pattern once set became the standard for all the narrow gauge lines. Some railway authorities in part partake of the quality of sheep —if the bell-wether leaps over a stick at a certain spot, all the other sheep leap at the same spot, even though the stick be withdrawn. And so double-head rails, cast-iron chairs, and cross sleepers became the standard practice, because under certain circumstances they had once answered well.

There was another form of rail devised by contractors for railway making, which was called temporary way, because it was taken up after the earthworks were formed and the ballast laid down, and thus the way which replaced it came to be called permanent way, because shareholders and directors hoped that it might be permanent, and not need replacing. The contractors' rail was very light and of very little vertical strength, being shallow and single-headed, but with a wider foot or base so as to stand upright on the temporary cross sleepers, and thus dispense with chairs altogether.

The first railway in America—the Baltimore and Ohio—was at first laid with flat tire-bar rails on longitudinal timbers. The Americans were not long in discovering that this would

not do, as it turned up at the rail ends, forming what were called "snakes' heads," which occasionally speared passengers through the carriage floors. So they imported the contractors' or flat-foot rail from England, of light weight, which was spiked down in a slovenly manner either on cross or longitudinal sleepers, and was thenceforward called the American rail, and lauded far and wide for its cheap system of construction. It was not really cheap. The American permanent way was the English temporary way, and the want of iron they endeavoured to compensate for by an extra quantity of cheap timber sleepers. The American railways were produced at low cost compared with the English, because they had no law or parliamentary expenses, no landlords to exact black mail for land and damages, all level crossings, no ballast or fencing, timber sleepers at one fourth cost, and bad iron reduced to a skeleton in scantling. There is a well-known story of a Welsh iron-master, who, being reproached for the bad quality of his rail-iron, pleaded as a set-off that he had been paid in bonds of a similar quality. And in working the lines a similar economy prevailed. For the host of signal and policemen prevalent in England, the

Americans for the most part were content with putting up an overhead plank across the line, and on it a legend, "Look out for the locomotive when the bell rings." Of course, in thickly peopled American localities, this sort of thing would not go on for ever, and here and there in New England, lines approximating to English lines are found. But the notion going about the world that American lines are cheaply constructed, is grounded on the fact of scarcity of material and labour in their construction at the outset. They were scarcely better than our private colliery lines.

Two systems of railway have obtained in England, known as the broad and narrow gauge. In Ireland, some six or seven gauges prevailed at one time. The English systems are respectively 7 ft. and 4 ft. 8½ in. width of gauge. Why a fractional measure should have been selected has puzzled many people, but the fact seems to be that the original cart track of five feet outside the wheels was taken as a standard for the gauge of rails, which were measured outside also. The width of the rails being originally 1¾ in. each, gave, therefore, exactly 4 ft. 8½ in. inside measure. When subsequently the rails were widened to get broader bearing and greater strength with

the same gauge, they were widened outwardly, because the flanges of the wheels could not be altered, so that the inner gauge remains 4 ft. 8½ in., and the outer 5 ft. 1½ in. French logicians would not have done this had they been the railway originators, but as they imitated us, they have taken our fractional gauge also.

The original Irish gauges, varying from 6 ft. 2 in. downwards, have subsided under the ordinance of the Railway Commissioners to a standard 5 ft. 3 in., and our East Indian gauge is 5 ft. 6 in. The process of arriving at the Indian gauge was the consideration of locomotive structure, to obtain ample room without cutting and carving the machine. The process of arriving at the Irish gauge was at one time stated to be that of adding up all the various gauges together and then taking the mean, thus meting out equal justice to Ireland, and at any rate preventing second-hand rolling stock being palmed on them from England.

The Spanish national gauge is 5 ft. 6 in., the same as our East Indian. A concessionary who had obtained a line in Spain and the whole of the rolling stock from the government at a given price, made an offer to reduce the price if he was permitted to adopt

the English gauge of 4 ft. 8½ in. The offer was tempting, but it was refused, for somehow they had got a notion that the contractor would furnish the line with second-hand rolling stock.

The Great Western line happened to be under the control of an ambitious functionary, the tendency of whose mind was to prefer the great to the useful, and the new to the old. He worshipped "bigness" in the abstract rather than symmetry or proportion, and he thought that the London and Birmingham running north, and the Bristol west, they would never come together, nor did he wish it, being desirous to be the ruler in an especial district of his own, and so he chose the seven feet gauge.

Now there are data by which to determine the choice of a gauge. The narrower the gauge the less will be the friction of the wheels, especially on curved lines, and where great speed is wanted, friction between the wheels and rail by sledging instead of rolling is one great element of retardation. But there is another element to begin with. The object of the railway is the transport of passengers and goods. Goods may most of them be divided into parcels of small bulk, but the

stature of mankind cannot so be treated, and therefore the sitting or standing height of man must be taken as the datum line for the height of a vehicle, if covered in. To ensure steadiness the width should be greater than the height, and the length three or four times the width. The 4 ft. 8½ in. width of gauge is ample for all this, for a carriage six feet high and nine to ten feet wide can run steadily on it, if long enough, and therefore on the broad gauge a carriage thirteen feet wide might run. But probably an integral five feet gauge might be an advantage to give convenient space to the engine.

The original object of the seven feet gauge was said to be to lower the centre of gravity and increase the size of the wheels by keeping the carriage-bodies between them instead of above them, as was and is the case with the narrow gauge, and also to give ample space for the large engines. But no structure of line has displayed so much want of plan or system. The first carriages, though the gauge was 2 ft. 3½ in. wider than the narrow, had no greater length than the narrow, and were too short to be steady. The wheels were 4 ft. 6 in. in diameter instead of the 3 ft. diameter of the narrow gauge, and they were placed outside the carriage-bodies, but inside the

frames, and the bodies were widened above the wheels, presenting the section of an old-fashioned clock-case, while the door-case projected to the width of the frames. The seats were inconveniently placed, and the carriages jumped, and the whole thing was a failure, the carriages being very shortly put out of use. Possibly they may be found in the company's sheds, but if not, they are recorded in Mr. Wishaw's quarto volume. The earlier engines were of less power than those of the narrow gauge, and the horse-boxes, originally made to carry horses sideway to the engine, had to be cut in two to carry them face to the engine, and to this day present the curious anomaly of vehicles broader than they are long, carried at high speeds.

The original structure of the permanent way was also original of its kind. Piles of timber were driven into the earth along the line of the rails at 15 ft. distances. To these piles, connected in pairs by cross timbers, were fastened half balks of timber, 7 in. deep by 14 in. wide, resting upon the earth; on these half balks were spiked oak planks 1 in. thick, at which joiners worked on their knees to plane them to a perfect level. On these were laid bridge-rails, *i. e.* a hollow bar with flanges at the sides secured to the timber by

nut-head screws on the outer flange, and by notch-head screws on the inner flange to keep them out of the way of the wheel flanges, felt-cloth being laid under the rails to make them soft to the movement. Eight different patterns were tried in succession, weighing from 44 to 62 lbs. yer yard, and even to this day no thoroughly satisfactory result has been obtained with the bridge-rail.

On the first trial it was found that nothing was right. The timbers and rails played up and down elastically between the piles on which they rested, and striking occasionally in water lying below the timbers splashed it over the train, while the passage over the piles was like a series of blows, and the motion of the short carriages shuffled the sitters off the seats. This kind of way was laid from London to Maidenhead, and "the first trial proved the fact" that it would not answer, so the piles were removed and the longitudinal timbers were framed together by cross transverses, and laid on the ground like an endless ladder, secured only by their own weight. The carriages were set aside and replaced by others one half longer, upon six wheels, and at the present day there is not left upon the line a single construction—either engine, carriage, waggon, wheel, or spring—as originally designed. The

solitary principles of construction are the seven feet gauge, and that, by common consent, is too wide for utility or economy, and the bridge-rail, which has only one advantageous feature —being laterally stiff. All the rest consists of a series of contrivances got at by the process of trial and error, finding out what would not do successively, and a narrow gauge line is now gradually pervading the space between the broad gauge.

While new, this kind of line—the bridge-rail on longitudinal timbers—answers very well, and possibly with light engines might be tolerably permanent. The broad timbers and broad rail are well calculated to resist the lateral blows of the wheels without the gauge being affected, but as the rail has very little vertical strength, it bends under the heavy weight on the wheels and crushes in the timber, occasionally splitting it lengthwise, and loosening all the fastenings. The processes tried experimentally to get over this difficulty have been many—changing from screws to bolts, enlarging the nuts, and cross-boarding the longitudinal timbers with short planking — but without positive success in any. Finally, it has been found that the bridge-rails tend to split open across the hollow as wear goes on, and attempts have

been made to replace it by a gigantic American, or flat-foot rail, but not successfully. All rails that are not deep enough to prevent bending under the loads must fail, and in the ordinary mode of supporting a rail on its base, the base width should be at least double the height. The chair system admits of this. With a rail 5 in. in depth, the chair is from 12 in. to 14 in. spread. The bridge-rail without a chair is $3\frac{1}{2}$ in. in height, and 6 in. in breadth; the American rail is 3 in. in height, and 4 in. in breadth, and the foot-rail on the broad gauge is 4 in. in height, and 6 in. in breadth. But a large quantity of metal is wasted on this broad foot-rail, and, after all, inefficiently.

The broad gauge and the narrow have waged a long contest, like Guelphs and Ghibellines, marked by unscrupulous assertion on either side, but there has been as violent a contest between the longitudinal and the transverse sleeper system. A contest for speeds was once tried, and resulted in the proof that great speeds were safer on the broad gauge than the narrow. The reasons were plain enough to the mechanical philosopher before the trial. The broad base of the seven feet and the length of the vehicle prevented oscillation; and the width of the bridge-rail prevented

lateral movement. The double head of the narrow gauge having little lateral strength was subject to lateral movement between the chairs, as well as some amount of vertical movement, and the wood keys got loose, and the engine partly from these causes, and partly from want of balance, became so unsteady at high velocities, that the experimenter, though a strong partisan, became frightened and gave up the contest, and the broad gauge kept its reputation for the greatest speed, whatever might be the cost to the shareholders.

Originally, the double-headed rail was fastened to the sleepers by cast-iron chairs, both at the joints and intermediates, the joints being about two inches wider than the intermediates in order to receive the adjoining rail ends. As the joints were only confined by a wood key they rapidly worked loose, and the rail ends were crushed and hammered. To meet this evil the writer devised the arrangement known as the fish-joint, which, when well fitted and secured, had the effect of making the rails continuous bars, and the importance of this in ease and safety was quickly appreciated by travellers.

With the weight of the engines, beginning at six tons on the Manchester and Liverpool,

and now growing to some sixty tons,—engine and tender,—on the Great Western and other lines, the weight of rails has increased from 50 lbs. per yard to 84 lbs. and 92 lbs. per yard, and the weight of chairs from 14 lbs. to 42 lbs. each, or about 100 tons of metal per mile. Yet the destruction of the rails is such, by want of sufficient bearing surface in the chairs, and the destruction of the sleepers by want of sufficient chair-bearing, that an attempt was made at one period to resort to the American system with a greatly enlarged rail, but it was a failure; and now attempts are made, not to remedy the evil by removing the cause, but by palliating it, so a cushion of wood is placed on the bottom of every chair, which receives the blow of the loose rail.

Why does the rail get loose? Because it springs and grinds the small surface of the wood keys which are supposed to make it fast in the chairs. Now, all mechanicians know that in moving machinery, whenever "knock" or loose movement takes place, destruction rapidly ensues. The railway is a part of the engine, and therefore "knock" is fatal to its durability. There is nothing permanent about it, except its permanent cost, and the incessant

noise experienced by passengers is evidence of incessant blows.

Why, then, is a system persevered in which is so inefficient? Simply, that the first consideration is, how to replace a worn or damaged rail with the greatest facility. To this one consideration permanence is sacrificed, though there is no reason why a permanent way should not be constructed without "knock," and with facile removal of rails.

The first and most important consideration in a rail is that it should possess sufficient depth to constitute it a beam capable of distributing the load through a considerable space. It should also possess lateral strength to keep the gauge. The next consideration is, that the base should be considerably in excess of the elevation. If the rail be supported on its base, depth is objectionable on account of the mass of material required. But if the rail be suspended by the upper table, this difficulty ceases and another advantage ensues. When supported on its lower table the vertical web must be of sufficient strength not to collapse under the load; but when suspended by the upper table the web may be reduced as thin as it can be rolled, as nothing more is needed than to connect the top and bottom tables to-

gether, and thus ten pounds per yard may be saved on the weight of the rails, equal to sixteen tons of iron per mile. In addition to this, the destructive effects of the engine-wheels on the upper table of the rails will be lessened.

The next consideration is, that the rails should be connected together so as to constitute a continuous beam, not merely by an arrangement to give vertical support as with "fishes," but so as to give also lateral support.

The next consideration is as to the quality of the metal; that it should be homogeneous, and not imperfectly welded like scrap iron, so as to break up into fibres like timber, or a birch-broom, which is so commonly the case under heavy engines. It is very certain that steel will ultimately be substituted for iron, as the price will be reduced as well as the weight, and thus permanent steel rails will be realised at not much greater cost than the iron rails.

A stereotyped phrase amongst some authorities on railway affairs is, "With a good 75lb.-rail, a 28lb.-chair, good squared cross sleepers, and plenty of them, it is a very difficult thing to make a bad permanent way." Analysed, this really means no more than—"that has been my practice, and I do not mean to admit that I have been wrong or that any change is right." Great is Diana of the Ephesians!

In truth, as bad a permanent way as possible may be made of the materials with want of judgment in their disposal. There is a proverb about "food and cooks," very much to the purpose in reference to this.

There is much dispute on the subject of railway sleepers. Some argue that longitudinal timbers are best, some that cross timbers are so. Others that cast-iron is best, and others hold on to wrought-iron. The writer has come to the conclusion that all may be equally good, and that even stone may be advantageously used, if used with judgment. It is a question of facility of supply in the rail localities, in regard to cost. But it is also a question of climate. In climates where heat and moisture prevail alternately, metal is better than timber, and either wrought-iron or cast-iron may be used, provided the junction with the rail be such as to prevent "knock," or loose movement. But where climate permits, timber may be used judiciously, so as to add one-half more to the strength of the rail, both vertically and laterally, while diminishing the quantities both of timber and iron as compared with ordinary methods.

Timber is strongly advocated as giving elasticity, and it is maintained that without elasticity permanent way cannot be perma-

nent. But what does this assumed elasticity amount to. If there be elasticity in the rail it must be in the three feet spaces between the chairs, and therefore the result must be a series of alternate springing and rigidity. In a cast-iron chair there can be no spring, nor can there be elasticity proper in the five inches depth of timber sleeper on which the chair rests. The chair absolutely sinks into the sleeper under the blows of the rolling loads, indicating plasticity rather than elasticity, and it is a fact that sleepers mostly wear out mechanically, and not chemically by rotting. Neither can the ballast below the sleepers be elastic. The use of the sleeper is analogous to that of the wood key—it cushions the knock when it occurs, and prevents iron from crushing on iron, or producing a ringing sound. The writer has tried the same rails on the same ground, both fixed on wood and on cast-iron, and found no difference whatever as to their durability, though on the timber the ringing sound of the wheels is more muffled. If a railway is to be elastic for the purpose of saving the rails, it is clear that it must be at the cost of haulage, as the level is destroyed unless a very costly system of construction be adopted. It would certainly be thought a curious proposition to

make a Macadamised road surface elastic for the sake of saving it, though there is no doubt that a very important advantage is gained by a soft bedding of earth below the stone, and making the vehicles elastic.

One great distinction in the structure of Macadamised roads and railways is, that the former are surface-drained, and the latter are, or are supposed to be, under-drained. The surface of the Macadam is a kind of rude tesselation, laid in a curve from side to side, so that rain does not enter, but falls off sideways. The railway sleepers under the best circumstances are laid in porous ballast, supposed to be from twelve to eighteen inches thick below them, and rising upwards nearly to the rail level. The weight and blows of the engines incessantly drive the sleepers down into the ballast and crush and consolidate it, so that if originally porous it ceases to be so, and in very wet weather every sleeper lies in a pond of water, which causes them to sink irregularly, and to spring up again ready to make another blow with added momentum. And however much a road may be out of order it cannot be "opened out" in rainy weather to "pack." The process of packing is thus. The ballast is dug out about twelve inches to the level of the sleeper bottom, and

then with rammers the ballast is beaten in below the sleeper bottoms to raise them. But as it is only the weight of the rail and sleeper which serves as a fulcrum to pack the ballast against, it is impossible that any amount of skill can measure the exact resistance so as to make the pressure equal, and if unequal the level will soon again be lost. And as the upper ballast which is filled in is not consolidated, it remains like a newly dug garden bed, an absorbent to conduct any rain which may fall, direct to the sleepers. Yet, strange to say, a notion prevails, that by sinking the sleepers low down in the ballast they can be kept drier, the fact being that the lower they are down the more is the difficulty to get at them and keep them in order, and the greater is the amount of ballast required; and the nearer the bearing is to the surface the more is it out of the way of the sinking rain, and the less is the ballast required.

Stiff clay would be as good a material as any other to lay railway sleepers on, provided it could be kept in a condition neither too dry nor too moist. There are railways of incessant traffic, where it is desirable not to be frequently opening up the surface. In such a case, a subsoil of clay paved with flag-stones or slate

over the whole surface would be a perfectly available arrangement. "But it would be too rigid!" the "authorities" will remark, and they will quote the granite wall rail-bearers of Jesse Hartley, and the solid rock bearing of George Stephenson, in proof of the mischievous effects of rigidity. But they will forget to tell that these were instances of "knock" between three hard, *loose* substances —the rail, the chair, and the rock bottom. Had they made an engineer's fit between rail and chair—immovable—and a similar fit between chair and rock—also immovable—and had they also made rolling wheels instead of half-wheels half-sledges, with springs bringing the wheels in constant contact with a smooth and true-surfaced rail, we might have had a different result.

But a simple way of getting over the difficulty would be to lay the rails embedded in timber, and bolt the timber down to the paved surface. Then, with efficient machines, there would be a really permanent way. It would be worth while for the Great Western, or the South Wales, to try the experiment of placing thick slabs of sawn slates instead of ballast between these longitudinal timbers, securing ample surface to prevent rocking.

CHAPTER V.

STATIONS, BRIDGES, AND WORKS OF ART.

MATERIALS — PRINCIPLES OF STATION STRUCTURE — RAILWAY ARCHES—NOISE—VIBRATION—BRIDGES: STONE, BRICK, CONCRETE, WROUGHT-IRON, CAST-IRON, WIRE, TIMBER—ELASTICITY—PRINCIPLES OF BRIDGE STRUCTURE IN VARIOUS MATERIALS—SOUTHWARK—HIGH LEVEL: NEWCASTLE—WATERLOO—BRICK AND HOOP-IRON GIRDERS: BLACKWALL RAILWAY AT THE MINORIES, DEE BRIDGE—SUSPENSION BRIDGES: COCOA FIBRE, RAW HIDE, CHAINS — MENAI — WIRE BRIDGE — NIAGARA — BRITANNIA BRIDGE, HOLLOW BEAM OF WROUGHT-IRON—PROBABLE DETERIORATION BY RUST — ST. LAWRENCE TUBULAR BRIDGE—BEAM BRIDGES—BOWSTRING BRIDGES—SUSPENSION BEAM BRIDGES, SALTASH—NEWARK DYKE BEAM—OUTLINE BEAM BRIDGES, AMERICAN — QUESTION OF SPAN—PIERS IN ROWS—COFFER-DAMS AND CYLINDERS BRICK LINED—SCREW PILES—RAPIDITY OF EXECUTION OF IRON BRIDGES AND PIERS—GREATLY REDUCED COST—FLAT SLATE ROOFS FOR STATIONS AND BUILDINGS.

BY works of art upon railways are understood fixtures supposed not to require renewal during a long course of years. They consist of stations, platforms, tanks, warehouses, viaducts, bridges, sheds, arches, tunnels, culverts, and similar structures.

With regard to the materials of such structures, the governing principle should be the greater or less facility of obtaining them in their several localities. But as far as possible they should be permanent, and not decomposing or combustible, though under some circumstances quickness of erection must be taken into account.

There is another principle that should obtain. It is rarely possible to predict the amount of accommodation that will be wanted at a railway station, and especially at a terminus. Therefore as much land as possible should be obtained, because there is no risk of waste outlay, for it will inevitably rise in value. And the whole structure should be set out on the principle which governs the beehive—capacity for indefinite extension. Any fixed and decided symmetrical structure is to be deprecated, as needing subsequent pulling down in case of enlargement. Whoever has watched the enormous outlay at London Bridge stations, consequent on construction, and destruction, and reconstruction, and repeated purchases, will readily comprehend this. Could the companies at the outset have bought up the whole property for a mile in length from the railway to the river, it would have been

better for themselves and for the public also. They could have remained as renters of the property till they wanted it for use. And more thought would have enabled them to make useful buildings of their arches, by making them thoroughly dry and laying such a permanent way as would have prevented noise. One way and another the waste has been enormous, not at London Bridge only, but at all the other metropolitan termini.

The cost of railways is very largely enhanced by the number of the bridges required by reason of the general level surface needed for the rails, thus entrenching hills and spanning valleys, and requiring bridges for the railway itself below, and for the intersecting roads above.

Bridges are made of stone, brick, concrete, wrought or cast-iron, wire, and timber.

The weight of the trains and the heavy vibration of the engines, renders the selection of the material a matter of considerable importance. If constructed of non-elastic material, as stone or brick, they should be massive enough not to move at all, unless the permanent way be so constructed as by its elastic action to intercept the communication of vibration to the bridge structure.

A stone bridge in its most elementary form,

may be a heavy flat slab of solid stone spanning an opening of small extent. It would really be a stone beam. The meaning of the word bridge is to abridge or shorten distance, by substituting a straight line for a circuitous path.

If the span be considerable a stone bridge must be made of stones constructed in a wedge form, so that when placed together the result will be an arch—semicircular, segmental, elliptical, pointed, or other. Every stone must lie flat against its neighbour, and the whole must be loaded with equal pressure, and the dead weight must be such that no passing load can disturb it.

It follows that the larger the surfaces of the stones in contact, the greater will be the difficulty of disturbing them; but large surfaces involve great weight, and, carried too far, might produce crushing.

But the smaller surface induces rolling and crushing of the edges of the stones. For this reason it is common to cut away the edges beforehand. Thus a considerable weight of stone is employed for the simple purpose of preventing the edges from crushing by movement of the joints.

The form of the stones in section is similar to that of the staves of a cask or barrel; but

the stones of the arch are kept in position simply by gravity. In the cask or barrel they are kept in position by the hoop externally, which compresses the whole. If the barrel be divided into two halves so as to resemble the arch of a bridge, in the process termed "cradling," a hoop is placed inside as well as out. Could the stones of a bridge arch be connected to a strong iron hoop above and below by being bolted between, the whole arch might become immovable, and thus comparatively independent of equal or unequal loading. In the stone bridge without the hoops, the weakest parts would be the upper and lower edges; with the hoops they would become the strongest. The stones could not roll on their surfaces as they could not be separated below, nor unequally compressed above. But with the introduction of iron in any part it would be better to dispense wholly with the stone, as a heavy and uncertain material, its chief valuable property being in some cases indestructibility by the atmosphere.

Brick Bridges commonly preserve the arch form of stone bridges, but though formed of separate bricks, they may really be regarded as a species of mosaic-work, in which the former are made to fit by the mortar or cement which

binds the whole into a conglomerate of more or less solidity. If the bricks and cement be of equal strength and tenacity, and equally proof against weather, the whole may be regarded as a solid conglomerate rock hollowed out below. But the strength consists, like the bridge of arched stone, in the compressile force of gravity, and its power to resist that compression without crushing.

Analogous to this brick bridge is the bridge of concrete or broken stone, mixed with lime or other cement. That also is an artificial conglomerate moulded into shape, and the arch resists like an arch formed in a chalk quarry. They depend upon the abutments, either a horizontal foundation or massive structure at the ends, capable of resisting the thrusting weight of the bridge.

Well-made brick or artificial stone is a better material than natural stone, because bricks can be made homogeneous, and require less labour to form, while natural stone is very commonly not homogeneous, and the structure peels, as we see in the Houses of Parliament. Cast-iron is a better material than stone to form arch bridges, because it is better adapted to resist crushing, and may be made in larger pieces with fewer joints, and at the same time with less weight, a series

of hollow wedges being substituted for solid ones. One of the finest examples of such a structure is the Southwark Bridge over the Thames. A very remarkable bridge for strength is that High Level spanning the river Tyne, at Newcastle; but there is an architectural deformity in making upright supports pass through arches. A material should represent itself and its own capacities, and if a bridge be built of cast-iron it should not represent a stone one.

Cast-iron is, on the whole, a more durable material than stone. It will rust on the surface, but the rust forms a coat to prevent further rusting. But as iron differs in quality, it is needful to have regard to the chemical composition, or we may fall into the difficulty of a decomposing material like the stone of the Parliament Houses.

The disadvantage of arch bridges is, that the height of the opening decreases from the centre, and therefore they must be made more lofty; this throws their roadway higher, and so it is common to make the road slope down from the centre to each end, decreasing the size of the arches. Waterloo Bridge, a dead level, is formed of a series of equal arches, uniting the slope of a hill on the north side

of the Thames, with a road on the South to meet it, formed of a series of gradually diminishing arches till it meets the level of the ground.

The desirability in so many railway bridges of keeping them as thin as possible vertically, so as neither to interfere with the level of the railway below, nor that of the roads above, led to the construction of what are called beam bridges. The principle on which a beam carries a load is that the upper surface resists compression, like the bow of an archer, and the lower surface resists tension like the string to the bow. In brick or stone there is no quality of tension, but there is a process by which brick beams have been made. Through the joints, at a certain number of courses in the lower side, iron hooping is applied from end to end. Thus a tensional resistance of the iron below is made to compensate for the compressive force on the upper courses. A very flat brick arch was once built of great span, which excited great curiosity in the engineering world, but it was a trick, the hoop iron being concealed in it. There is no doubt that if the bricks and cement be good, a very permanent beam may be made in this mode, inasmuch as the

iron hooping is completely guarded against rust.

Cast-iron girder beams of moderate span, with a large amount of metal in the lower edge to compensate for the want of tensional strength, answer very well, and so might larger spans answer in parts, provided the needful tensional force were supplied in wrought-iron below. But there is a curious example in some existing cast-iron girders of want of engineering perception in structure. The girders are cast in three pieces and bolted together at the ends by projecting flanges. Wrought-iron stay bars are attached diagonally from the tops of the end beams to the lower side of the middle joints, apparently with some notion of strengthening the compound girder, but in reality only adding weight to it without utility. The effect is neither more nor less than that of the exploded process of tying a horse's head up to his own back by a bearing-rein to prevent him from falling on his knees. It is probable that were heavy engines and high speeds used on this bridge it might be found inefficient. A bridge which broke down some years ago was of similar structure, and gave way on being loaded with an extra six inches of

gravel to prevent the planking of the floor from being burnt by hot ashes from the engine fire-box.

The oldest known bridges are the suspension bridges, taking their rise probably from the wild vines or tensile plants hanging from tree to tree in tropical regions. In eastern India this natural process is imitated by ropes made of cocoa-fibre, bamboo, or other material. In South America raw hide ropes are the material preferred. They are used for the purpose of crossing deep torrents where no ford or ferry can be obtained. Two trees are erected on each side the opening, at a sufficient length and breadth apart. The tops of the trees have a natural fork, over which the twisted hide ropes pass, well greased but not tanned. At a sufficient distance from the trees posts are driven in as anchor-blocks, to which the ends of the ropes are secured, hanging down in a slight segmental curve across the opening. Sticks of a sufficient length and from one to two inches in diameter connect the ropes together and form a flooring over which human beings and cattle pass. In the dry climate the ropes last many years unless they get gnawed by beasts of prey.

In our English imitation of these bridges

we do not make the chains which supply the place of the hide-ropes a roadway, but suspend a straight roadway from them by vertical rods, as may be seen in the example of Telford's suspension-bridge over the Menai Strait. But the objection to it is, that as there is no sufficient longitudinal stiffening in the roadway it wavers under a passing load. The fact being so, no one in English railway practice took the trouble to ascertain whether it was a necessary condition of the suspension bridge, and so the wrought-iron beam bridge, in one form or another, became the established rule.

But wrought-iron beam bridges, and especially in the United States, are costly things, and therefore an American engineer wishing to span the Niagara river with a railway bridge of 820 feet span came to the conclusion that it was possible to use the suspension principle without any difficulty by stiffening the roadway with a sufficient timber framing. The principle of chains with very long links is used in the construction of the Menai and other bridges, but the engineer of the Niagara Bridge preferred wire, because the strength of wire with a given weight is three times or more the strength of iron bars.

And so the engineer constructed his bridge with wire and timber, and railway trains have run regularly over that and similar bridges from that time to this. The advantage of the suspension-bridge is that the metallic portion is disposed in the form to take advantage of its utmost strength. And wire cables can be perfectly and entirely secured against rust. The only chance of defect is putting an unequal stress on the separate wires, and which, if carried to too great an extent, might break them in succession.

When the Chester and Holyhead Railway was in course of formation it became necessary to cross the Menai Strait, as Telford had done before in the formation of the horse-road, and the Admiralty were determined, as in Telford's case, that the navigation should not be interfered with, and that a clear breadth of at least 100 feet should be left the whole length of the bridge—and so Robert Stephenson set to work. His first thought had been a cast-iron bridge, but that was impracticable under the conditions, and so he turned his thoughts to Telford's suspension principle, which had almost a span of 580 feet. How to make a rigid roadway to suspension cables was the consideration; and

it occurred to the engineer that he had once seen an iron ship aground rocking on her mid-length without damage, and he thereon thought that a circular tube of wrought-iron suspended at the centre by chains from towers 460 feet apart would effect his object.

And thereupon experiments were made as to the requisite strength of material. The circular tube was found to collapse, and gradual experiments resolved it into a tube of oblong section with vertical parallel sides and horizontal top and bottom. But this tube also collapsed, and it was found necessary to strengthen it with a double top and double bottom divided into long compartments, like a series of small tubes. This gave compressional resistance above and tensional resistance below. But the strength of a beam depends upon the distance between the top and bottom, and the preservation of that distance, and so it was found needful to attach stiff ribs to the sides vertically, in order to prevent them also from collapsing. The experiments on the circular tube were never followed out to their conclusion.

If we examine a hollow bamboo cane we find that at certain intervals nature has stiffened it by a diaphragm inside and a circular

projection outside. Of course, as the railway tube was intended for trains to pass through it, it was not practicable to put diaphragms in the inside, but circular diaphragms might have been put outside connected by longitudinal ribs, and supposing that such a tube with a given quantity of metal could have been made equally strong with a square one there would have been the advantage of a clear inside and an outside accessible in all parts, so that the whole of it might have been examined without difficulty. There would have remained the objection of the square train passing through the round tube, but the structure would have been simple, and the original idea of Robert Stephenson would have been verified.

When the experiments were gone through, it was found that the tube was strong enough without the suspension-chains, and so the hollow beam became a practical fact, considered at the time a new wonder of the world. And in truth, considering its magnitude, the length of span, the skill, energy, daring, and new processes that it involved, it might well stir men's minds; but, regarded as an object of utility, it falls far short of its cost, because its ultimate durability is very doubtful, or rather the destructive process certain; and it

may be predicted that when it yields to time, it will not be replaced in its present form, and ordinary repairs, taking away gradually, and replacing, are not practicable. Some day the press will ring with an alleged subsiding of the tubes, and many learned treatises will be written upon it to prove that they must and ought to fail.

* Each tube from end to end is 1511 feet, the two together 3022 feet. In this pair of tubes there are sixteen top-cells, or small tubes, running the whole length, and measuring 1 ft. 9 in. in height and the same in width. There are also twelve similar cells at the bottom, 1 ft. 9 in. in length and about 2 ft. 4 in. in width. Therefore the total length is about eight miles. It may be said that these cells or small tubes are open, and may be examined from time to time. But the cells are all in darkness, and with the heating action of the sun on them a violent rush of air takes place if both ends are open; and to examine them the engineer must creep on his hands and knees, and manage his light as he best can, or he must be dragged through on a sledge. He must be a very lithe and active engineer who can examine thoroughly the top, bottom, and sides of such a structure, and make sure that

all is attended to in an unbroken stretch of 500 yards.

The atmosphere is saline, and during the construction the iron suffered severely from rust, which it was very difficult to scrape off, and the particles of paint had to be removed together with the rust. Now, no amount of scraping can remove rust from rough plates and irregular joints, and however we may cover it with paint, the rust will go on again. Unless, therefore, these small tubes be all hermetically sealed against the saline atmosphere, rusting is probably going on over the large internal surface. The vibration of the trains which shakes out rivets from time to time will also shake off the coats of rust and expose fresh surfaces, gradually thinning the plates, the surfaces of which in their cells alone are equal to about eight acres, saying nothing of angle iron-edges and rivet-heads and covering-plates, and, supposing that the joints are all good, the plates of the cells three-eighths of an inch in thickness, and supposing that there be sufficient admission of saline air, the destruction is merely a question of time, unless the internal inspectors and painters be very conscientious men.

After some accidents to cast-iron bridges,

considerable numbers of small hollow beams of sheet-iron were applied throughout the country, and they will be generally found in wet weather to be dripping with red rust. Accidents are not likely to occur, as in the case of cast-iron, because they will give timely warning by bending before they break.

Another bridge on the tubular principle, for the trains to pass through, has been constructed —that over the St. Lawrence. Much assertion has been made as to this being a more wonderful construction than the Britannia, but in truth it is less so, the spans being longer in the Britannia, and in bridge structure the chief difficulty lies in the extent of span. An additional number of spans is no more than an additional number of cells to a beehive. An engineer might as well take credit for the number of piles he had driven, or for the number of piers he had built. The engineering merit lies in devising the pattern of the first structure, not in the multiplication of it.

Apart from the objections to these close tubular beams, in the difficulty of maintenance and expense, they involve a considerable waste in material. The thickness of plates on the sides is about half an inch. Less than half this would avail for the absolute strength re-

quired, but extra thickness is required to hold the rivets and to guard against the effects of rust. Moreover, a hollow tube involves a large amount of noise. Whenever plate bridges are now erected they are simply open beams—a compressile top of wrought or cast-iron being connected to a tensional bar or links below, by the plates.

But it is found better in practice to use the iron in wrought beams in a series of open framework instead of continuous surface, for a less amount of iron will then suffice, and there is a much smaller surface exposed to the action of rust, while the fastenings instead of being an enormous number of uncertain rivets, are a small number of accurately fitting bolts, and an open framework is less exposed to damage from wind. There is one advantage in the hollow tube, that the resistance to buckling is very great by reason of its height and width, and this is the chief difficulty in constructing beams to resist pressure. A bar of iron of a given length would resist as great a weight with the load resting on it endwise as it would suspended from it, provided only that it were secure against flexure.

Beam bridges are of various kinds, but when the parts are fixed together they consist

in principle of a tension bar below and a compression bar above, connected together by vertical or diagonal bars, the distance apart, or height, being about one-tenth or twelfth of the total length between the supports. All true beams are self-contained, *i.e.* they do not require abutments as is the case with arch stone bridges. But beams are occasionally cambered or slightly arched, and made to rest against abutments, which adds very materially to their strength, and an example of this class of structure may be seen in the New Westminster Bridge, where arched frame beams of wrought-iron impinge against cast-iron abutments.

Self-contained beams are both arch form, and of parallel tops and bottoms. The former can be constructed with the smallest amount of metal, but they involve a great variety of parts and more uncertainty in the manufacture, otherwise theoretically they are the best form. Samples of these may be seen crossing over the Regent's Canal and the Commercial Road, near London, the bow above being formed of a curved inverted trough of wrought-iron, the ends abutting against the chain of links like an archer's bow, and the bow and chain, on which latter lies the floor, connected together

by tie-rods and diagonals of unequal lengths, adjusted by a large number of keys.

In ordinary suspension-bridges the strength depends upon the resistance of the anchors or masonry to which the chain ends are attached after passing over the towers. At Chepstow this anchoring is dispensed with by attaching the ends of the chains to the towers themselves. But as the load would tend to pull the towers together, large iron tubes of oval section are stretched from tower to tower to form a resisting framing. This, therefore, may be called a frame suspension-bridge, carrying a roadway by suspension-chains from the frame. There is no advantage in this mode of construction, and there is considerable ugliness. In the Saltash bridge suspension-chains are attached from the ends of the bow, but this complicated arrangement has no advantage over the Britannia tube other than that the insides of the tubes are easily accessible to repair, and the trains run with less noise, and the blows of the wheels are not directly upon the tubes.

The Newark Dyke Bridge is a sample of a straight beam with the top compression-bar connected to the lower tension-bar by a series of diagonal struts and ties. The strength of

this beam depends upon the power of the chains to resist tension and the power of the top compression-bar, and also of the diagonals to resist buckling.

The tendency to buckle being in proportion to the length of the bar, it follows that the stiffness and weight must increase in proportion to the length. Thus on a bridge of this construction, a span of 258 ft. will require diagonals about 24 ft. in length. If the diagonals were only half the length, one quarter the sectional area would suffice.

This advantage is attained in the lattice bridge, the simple principle first applied by the Americans, with timber for a material, and of which a sample was exhibited in Pedlar's Acre, at Lambeth, about the year 1812. In this case the diagonal lattices intersecting each other at short intervals and fixed together, acquire a greater amount of stiffness in each diagonal.

But there is also required a general stiffness throughout the whole beam, and the best mode, and probably the cheapest on the whole, would be to make double beams bolted together with distance joinings. In large spans the spaces between might thus serve for foot passengers.

The strongest beam bridge in existence is

the Charing-cross Bridge, now replacing the Suspension Bridge, about to be removed to Clifton. It is, in truth, a pair of hollow beams, composed of a double lattice-work connected by transverse struts and bolts, holding together a compression bar above formed of wrought-iron plates riveted together in a channel, and a tension chain of riveted bars below. Thus the tendency to lateral "buckling," which is the defect of ordinary lattice bridges, is removed, and every part is accessible for examination, painting, and repair.

As regards cost, the tension principle of wire is the cheapest and probably the safest. Comparing the Britannia hollow wrought-iron girder with the Niagara Suspension Bridge, the former, with a span of 460 ft., has a weight of material of 1300 tons suspended between the supports; the latter, with a span of 820 ft., has only 1000 tons of material between the supports.

But whether the principle of wire ropes has yet been used in the best mode is still a moot point.

In the structure of bridges or viaducts the question of length of span is important as regards cost. Of course, over a river, the ques-

tion of navigation must rule. In other cases it is a question between length of span and depth of pier. When the piers are very lofty and costly it is better to diminish their number by using long spans. When the piers are short and cheap, short spans are the best.

In the structure of piers formerly, the practice was to enclose a given space with piles driven close together, then to pump out the water and lay the foundations as on dry land; and one great disadvantage from this was, that on pulling up the piles after the building of the piers a deep trench was formed, tending to damage the foundations of the piers.

Of late years coffer-dams have disappeared, or rather the system of pile-coffers has given way to a system of cast-iron coffers, forming the exterior of the pier. A series of castings are bolted together to form a ring of more or less diameter and depth; another ring is bolted to it, and another, till the bottom rests on the gravel or shingle. A diver then descends, and digging up the shingle from the bottom, sends it up, till gradually the cylinder sinks to the solid, when the water is pumped out, and a sufficient depth being attained, the cylinder is filled with concrete below water, and with gravel and cement above. Three or four

cylinders placed in a group in this mode, or any greater number, make a pier as perfect as can be desired, and the cast-iron cylinder is as durable as any stone surface.

If the bottom be rocky, hollow cast-iron piles, of two to three feet in diameter, can be inserted in holes formed by the diver and cemented in. If the bottom be sand or clay, the cast-iron screw-piles may be very effectually used, and they are the most rapid process. It is no slight matter in the progress of railways that cast-iron piles and wrought-iron girders will form bridges in probably one-tenth of the time and at one-tenth of the cost of stone bridges of the old fashion.

An item in railway structure of very considerable importance is, roofs, both for sheds, stations, and other buildings. It is desirable to keep all the roofs as flat as possible for many considerations. Flat roofs are easily accessible, not liable to get out of repair, and cheap. The best material for them is sawn slate caulked at the joints with an elastic material, and laid on timber or wrought-iron beams. Cast sheets of glass, of the same sizes as the slates, and similarly caulked, can be inserted at intervals.

CHAPTER VI.

MOVING STOCK.

DISCREPANCY BETWEEN PERMANENT WAY AND TRAINS—FRICTION OF WHEEL TIRES AND RAILS—SPRINGS—RAILS AND ROADS COMPARED IN PRINCIPLES—WEIGHT OF LOCOMOTIVES—LIGHT AND HEAVY ENGINES—NUMBERS OF WHEELS—MAXIMUM POWER, MINIMUM WEIGHT—COUPLING ENGINES—SPEEDS—SLIP.

THE term, "Moving stock," is French, and strictly logical. "Rolling stock" is the term used in England, first applied by Captain Huish, the Manager of the London and North Western; but it is not logical, inasmuch as the so-called wheels are not wheels proper, but a variety of garden roller, moving partly with a rolling and partly with a sledging motion. A wheel proper moves by rolling, a sledge moves without rolling.

It has been stated by "railway authorities" that railway accidents are caused by too great speeds, and that if safety is desired it is essential not to travel at a greater speed than thirty miles per hour, unless the permanent way be

replaced by a more efficient structure at a greatly increased expense.

That accidents are largely increased by a discrepancy between the permanent way and trains there can be no doubt, but it is very doubtful if any amount of cost could enable a permanent way to be constructed that would be really permanent under the present system —or rather no system as regards principles— in constructing the engines and trains, and the writer is of opinion that the present cost of construction is ample, provided the materials of the way were disposed in the best form for efficiency and durability; and provided, also, that the trains were made really elastic bodies, and the wheels were made to roll perfectly instead of sledging along the rails as they now do. If any one doubt this, let him carefully watch the rails as they glint in the sunshine during dry weather, and then reflect that this glint cannot be produced by the mere transfer of surface which constitutes the true rolling movement, but is produced by the gliding or sledging movement technically called "burnishing," *i.e.* friction; the rails are, in short, polished by the friction of the wheels, just as the axles are polished by the friction in their bearings. If doubt still exists, let any

doubter carefully brush and wipe off the rail surfaces before the arrival of a train, and after it has passed, rub a white glove or handkerchief over the same surfaces, when he will find it covered with finely powdered iron dust resembling black lead, and if he then dips the handkerchief in water and dries it, he will find it thoroughly iron-moulded. So long as the wheels shall be constructed as at present, this process will go on deteriorating both wheels and rails and increasing the cost of haulage.

But there is another defect. The want of sufficiently elastic springs to ensure the constant bearing of the wheels on the rail surface causes both engines, carriages, and waggons to jump at inequalities, and if the substratum of the sleepers be too firmly bedded to yield, the rails will be battered to pieces, and it may happen that a railway in bad order may involve a greater amount of resistance per ton than a macadamised road in good order.

A railway is superior to a highway in four essential principles, if rightly constructed.

1. That the impact of the wheels is on a hard and unbroken surface.

2. That the surface is non-deflecting either vertically or horizontally.

3. That it is reduced to a practically horizontal level.

4. That the wheels are self-guided, so that the wheels running on the rails are protected from lateral collision with other vehicles.

But these conditions on a line of railway used for locomotive engines must have reference to the construction and weight of the locomotives that run on the rails, and the structure, connexion, and bearing surface of the rails themselves. The railway and the trains are all parts of one great machine.

If the joints of the rails be not such as to make the whole line resemble a continuous bar, there will be a waste of engine power and a constant necessity for repairs.

If the bearing surface of the rails be not sufficient they will crush the chairs; if the bearing surfaces of the chairs be insufficient they will crush the sleepers; if the sleepers have not sufficient bearing surface they will sink into the ballast.

If the rails be not stiff enough vertically they will deflect, and sleepers and ballast will be crushed in detail.

If the rails be not stiff enough laterally, to prevent deflection, the engines and carriages

will oscillate and be unsafe, and rails and road will be rapidly destroyed.

But if the rails be made as stiff and as hard as possible and the substratum so firm that no rolling load can deflect the rails, there will still be a limit to the weight that can be placed on each wheel; because with a sufficient weight the rails and wheel-tires will laminate and crush, the impact being commonly a point and at most a line two inches in length. From four to five tons on each wheel is the utmost limit of weight that can be applied without crushing, with ordinary materials. If this weight be exceeded we must take to rails and tires sufficiently hardened, and then cost becomes a consideration.

It is true that engines with twelve to fourteen tons on a pair of driving wheels do occasionally run on rails without crushing or laminating the rails very rapidly. But in such cases it will be found that the rails deflect, and the crushing is transferred to the sleepers and ballast. And the engine in such cases wastes a considerable portion of its power in constantly ascending inclines.

This leads us to the consideration of the quality of engines. By the terms "light" and "heavy," we must understand the proportion

that is borne to the substratum and rails on which the engines run. An engine may be light as regards one line and heavy as regards another.

And even supposing the heavy engines to possess more power than the light ones it does not follow that they will draw a heavier train, because they lose power by the constant deflection of the rails. Moreover it must not be forgotten that the engine has to move its own dead weight as well as the dead weight of the train, and the heavier the engine in proportion to its haulage power the greater will be the disadvantage. It is analogous to the case of a pony and a heavy horse on a yielding bog—the pony works best, because he does not sink into the bog.

But there is another consideration. Up to a certain weight, engines carrying their own fuel and water may be perfectly safe at any speed. Beyond that weight the number of the wheels must be increased, and after that a tender must be added, still increasing the number of wheels. And every increase in the number of the wheels, unless provision be made for free lateral traverse to enable each pair of wheels to seek the path of minimum friction, will disproportionately increase the resistance

of the machine on the rails. It would be possible that in certain positions, such as reversed curves, the engine might be stopped by the mischievous friction of its wheels on the rails.

The real question is how to attain the *maximum* power with the *minimum* weight. By power we are to understand the surplus power remaining to draw a train after supplying sufficient to overcome its own gravity and friction.

Thus it may happen that a well-constructed light engine may be able to draw a longer train than a heavier engine by reason:

1. Of having less dead weight,

2. Of having less friction,

3. By not crushing and deflecting the rails, and consequently running on a better road. For by the terms "light" and heavy" are not to be understood, "small power" and "great power," for the small engine may have great power and the large engine small power. A boiler formed of a given thickness of plate 2 ft. 9 in. in diameter will bear higher pressure than a boiler of 4 ft. in diameter made of the same thickness of plate, and at the same time with less risk of bursting.

But it may be argued that trains are required imperatively of a weight and speed

beyond the power of light engines, and that it is better to *waste* power in drawing heavy trains, than to use power without waste and not accomplish the business required.

It is questionable if it be a desirable thing to use machines that break down the road rapidly, on the score of safety if not economy. A cheaper and simpler method would be to run two moderate-sized four-wheel engines coupled together at the foot-plates, so that one driver and stoker might manage them as they now do a single engine. The two engines so coupled would easily bend round curves, with little friction. And two engines so coupled would be safer in case of a wheel breaking than any ordinary six-wheel engine.

It may be objected that with two engines coupled together there would be the same result as with two horses coupled together—a diminished amount of available power for want of pulling uniformly.

The answer to this is that the two engines should be so coupled as to constitute one, and there might thus be eight wheels with adhesion, and less than four tons weight per wheel, which distribution would avoid damaging the rails or road.

With regard to the consumption of fuel, supposing all engines to be constructed with equal accuracy of proportions, a given quantity per ton of load will be burned, proportioned to the speed, the gradients, and the condition of the road. If, therefore, the heavy engine crushes the road, more coke will be consumed and *wasted*. And supposing no crushing, still every extra ton, or every extra pound of resistance in the engine itself, will represent so much extra coke.

If, therefore, an engine weighing 15 tons could, by extra pressure and reduced weight and friction, be made to draw as heavy a train as an engine of 30 tons, there would be a saving of coke equivalent to the draught of 15 tons, or two or three carriages, independently of the saving in friction and deflection, which might amount to as much more. High pressure is a good source of economy, making the engine, as it were, a blood-horse instead of a cart-horse. It is true that the higher the pressure the better must be the workmanship to resist leakage, and the better the covering to prevent radiation and waste of heat; but workmanship is constantly improving, and there is much room

for improvement in the arrangement of locomotives yet.

Another consideration is that the light engine may travel at far greater speed without damaging the rails or road, and though called light, the parts that are in motion are in reality proportionately stronger than the corresponding parts in heavy engines, while their less total weight reduces the amount of momentum and risk.

There is yet another consideration—*slip*. The real meaning of the term "slip" is, deflecting rails. If an engine on six wheels with middle drivers has much weight on the drivers while the leaders and trailers are light, the engine will be apt to pitch. If it has little weight on the drivers, the engine will be supported at either end, and the rails deflecting beneath the drivers, they will slip.

The light engine on four wheels will not deflect the rails, and consequently the driving-wheels will not slip. But supposing very light rails which do deflect, still the drivers will follow the rails and produce adhesion.

A strong argument in favour of light and powerful engines is their facility of great speed with little damage. They are less costly

to clean, and may be more constantly at work; consequently the journeys and returns may be much quicker, the public will be better pleased, and a smaller amount of engines will be required.

Of course, well-constructed trains should be used corresponding to such engines, and in proportion to the diminution of dead weight would be the diminution of momentum and the consequent diminution of risk, either of getting off the rails or of doing damage by collision. And, above all, the diminution of destruction to the road, which is the original cause of almost all mechanical accidents in the moving portions of railway machinery.

CHAPTER VII.

THE MECHANICAL CAUSES OF ACCIDENTS.

WANT OF EFFICIENT SPRINGS—ENGINE COMPARED WITH OMNIBUS—WHEELS—NOT WHEELS BUT ROLLERS—TIRES—MODES OF FASTENING, CAUSE OF BREAKAGE—CARRIAGES—BALANCE COUPLINGS—LUBRICATION—SPRING-TIRED WHEELS—COLLISIONS—SIGNALS—FISH JOINTS—RATIONALE OF EXPERIMENTS—POSSIBILITY OF IMPROVEMENT AND INCREASED SAFETY—DISTILLED WATER IN ENGINE-BOILERS—AMERICAN ROCK OIL FOR FUEL.

ACCIDENTS occur:

1. From the crystallisation and breakage of rails.

2. From the breakage of chairs.

3. From the falling out of wood keys from chairs.

4. From the sinking of sleepers and springing of rails.

5. From the crystallisation and breakage of tires.

6. From inefficient springs.

7. From sledging wheels.

8. From collisions, owing to the retardation of trains by inefficient power.

9. From collisions originating in gravity and momentum not sufficiently arrested.

Did any reader of these pages ever ride on a locomotive engine, not a driver or railway official, in whom use has deadened sense, or custom has caused a resort to natural contrivances to avoid dislocation of his lower limbs? Did any reader ever ride over a stone pavement on a scavenger's cart or a coal waggon without springs, or is there a man left alive who has ridden on the footboard of an aristocratic town coach or chariot without springs, and had the calves of his legs shaken down over his ankles, or the lower part of the muscles thickened till the legs resembled two bed-posts. Let such a man pronounce whether any or all of such vehicles are equal in pain-giving roughness to the footplate of a locomotive. An omnibus driver may work fourteen hours a day, for he is seated on springs, but the locomotive driver would fall down from sheer exhaustion long before he had stood that length of time, even while putting his own natural springs to work by standing on his toes, for to stand on his heels would be an impossi-

bility. It is remarkable how a stranger feels for the first time and can attend to nothing but holding on when mounted on an engine. It is not so bad as sea-sickness, but it is very like what an unsprung coal waggon would be if used as a mail coach at ten miles an hour over the stones. How a man can pay attention to driving or signals under such bodily punishment is difficult to understand, and it would be utterly impossible were not all the guiding of the wheels a self-acting process.

If the effects are such upwards, upon a human body of 140 lbs. weight, what must be the downward effect of 14 tons upon a pair of driving wheels jumping on the rails? Robert Stephenson was accustomed to say that a badly made waggon did more mischief to rails than a well-constructed engine. The amount of mischief resulting from a badly constructed engine we may imagine.

We may take it for granted that the great distroyers of permanent way are the jumping engines with merely nominal springs, and that until the driver of an engine can ride as easily as the driver of an omnibus, the engine constructor has made a failure in his work, and it is useless to expect to keep permanent way in order till the moving stock becomes really, and

not nominally, rolling stock. Let us begin at the beginning with wheels and axles.

The original wheels of railways were cast-iron, and for the facility of relieving from the moulds, the peripheries were made conical and not cylindrical. George Stephenson when experimenting for the Liverpool and Manchester thought cylindrical wheels would be better and had some so made, but for some reason or other they had a tendency to get off the rails, so he returned to the coned form, and a theory was made out by scientific people, that the coned wheels were a great discovery, tending to keep the carriages on the track, with the important quality of being enabled to run on increasing and diminishing diameters upon coned portions of the line, thus adjusting the diameters to the length of the track, and preserving a perfect rolling motion with both wheels fixed fast to a revolving axle.

The theory was plausible, but facts vary from the theory. In practice, large railway curves may be set out, but the rule is, an infinite quantity of unintentional small irregular curves which the cone system does not provide for, save at very slow speed, when a sinuous motion may be observed in the train

by the wheels rolling from side to side as impelled by the rail irregularities. 'When speed obtains, the wheels take no notice of these irregularities, but jump from lump to lump with a grinding movement. And so the cone disappears from the wheels, and a hollow surface takes its place, which grips the rails and stops free lateral movement, generating so much friction and strain that the wheels are necessarily removed and turned in a lathe to restore them to form.'

Practically they are not wheels but rollers, being fixed to a shaft, or axle, which revolves with them. The result of this is that the wheels, if of exactly the same diameter, can only roll forward in a straight line. If of varying diameters, they can only roll forward in a curved line, and consequently upon irregular rails they slide and grind with a vibrating movement, tending to crystallise both rails, tires, and axles, which latter are exposed to an enormous torsion in addition.

If the wheels instead of being constructed like a garden-roller, both in one piece, with the axle, were made to revolve independently of each other, the grinding, sledging, and torsion would disappear, and both wheels and axles might be made considerably lighter, and

a very large amount of risk and danger would be removed.

That this is not done arises simply from an existing prejudice that loose wheels, *i.e.* independent wheels, will run off the rails. Ever since railways commenced the obvious fact that loose wheels compensate for unequal diameters and irregular rails has been understood; but whenever it is proposed to adopt them for railways, old stories are revived how they have been tried and failed. The reason they have failed is plain enough—imperfect workmanship. On the Newcastle and Carlisle an ordinary railway wheel was bored out in the centre and left to run loose on the axle instead of being keyed on. As might have been foreseen, it ran a week, then got loose on the soft cast-iron, "got drunk," as the workmen phrase it, was taken off, and served thenceforth as a law and precedent against the use of loose wheels on railways.

Some years back the writer had occasion to call at the factory of the well-known engineer, John Hague, one of those original-brained men who are born with instinctive perceptions. Some Great Western wheels were in process of alteration, and it appeared that the engineer, Mr. Brunel, had resolved upon trying how

loose wheels would answer in reducing friction on the broad gauge. After examination the writer turned to honest John and asked, "How long do you think these will last?" John looked up to the roof for some time as though in the process of calculation, and then replied, "I think they may last a week, if they don't run them too hard." And so Mr. Brunel also became convinced that loose wheels would not do on railways.

But if the axles and wheels of an ordinary omnibus were made proportionately badly out of unfitting material, they would scarcely last two days. In truth, no one has ever yet made loose railway wheels as they should be made, and it is therefore assumed that no one can do it. What is required is, properly hardened axles and boxes of a sufficient length to keep the wheels steady, retaining the revolving axle, and adding to it revolving wheels. The axle will be found to continue its revolution, and the wheels will only revolve so much as to compensate for irregularities in the rails. But the important result obtained would be that the axle and wheels would be practically much increased in strength, as the risk of breakage would be much diminished. And another advantage would accrue; a larger bearing sur-

face might be obtained on the rail, saving both wheels and rails from such rapid wear, by making them cylindrical, to take a bearing across the whole breadth of the rail, and at the same time bearing vertically on the rail, instead of tending to thrust it outwards and unseat it.

The next question is of the tires. At the outset they were made of fibrous iron, and the wheels were light. But as the weights increased the axles gave way, the wheels lost their shape, and the tires spread out like dough or putty. So, from half a ton per set of four, they were gradually increased to a ton and a quarter. Ordinary people, who ride in an ordinary omnibus running over bad roads at eight miles per hour, with a load of thirty people, may or may not be aware that the omnibus itself weighs little over one ton, and still less may they be aware that the wheels alone of a first-class railway carriage, carrying eighteen passengers, weigh a ton and a quarter; but such is the fact, while the carriage complete weighs some five tons, the load being twenty-two hundred-weight to five tons, while the load of the omnibus is about thirty-seven hundred-weight to one ton.

Granular hard iron was substituted for

fibrous iron in the tires, and now steel is largely used. The tires are commonly applied by shrinking on hot, as is done by ordinary road wheels, but with this difference, that the road wheels being of wood, the wood is strained, but not the tire, in the shrinking process; but with railway wheels the tire is in a state of tension, and frequently of extreme tension, on the iron frame, instead of being, as it ought to be, in a state of rest. It is moreover pierced through the centre with many holes to bolt it to the frame, which alone diminishes its strength by a third, and the marvel is that, under such circumstances, tires do not burst much oftener. It is only the extreme risk that has caused attention to be paid to the subject, and now tires are applied without holes through them in a mode which may save them from flying off when they do burst. When the action of frost takes place on iron railway wheels, two evils ensue—the tire is rendered more brittle, and the axles shrink where the wheels are keyed on, so that the wheel shifts its position and gets off the rails.

Some years back a railway potentate was waked up from his slumbers on the North Midland Railway by the tire of a wheel bursting and forcing its way through the floor, with

a very narrow escape of his person. Arriving at a station he telegraphed for all the officers of the line, far and near, and when they were all assembled, flourished his walking-stick like a sceptre, and demanded who made the tire. On the names of the firm being given he ordered that thenceforth all such tires should be removed, and the firm no further employed. At that very time a large number of these tires were being applied to wooden wheels, but they were not heated and cooled in the process, only fixed on by cold pressure, and they have been in use from that time to this, without a failure, at high speeds.

There is a notion prevalent that tires must necessarily be shrunk on tight, but there is no greater fallacy. It is true that the tires of driving wheels which have to propel by their adhesion to the rails must be sufficiently tight not to slip on the wheels, but on ordinary wheels, if secured against coming off, they would be far safer, slightly loose, than if tight. The notion has arisen from the practice of road wheels, on which a tight tire is essential to hold the wood frame together, but no such need exists with properly made railway wheels.

In applying railway wheels and axles it is customary to apply them with the axles at

right angles to the central line of traction. On curves of great radius, and with loose wheels, this arrangement would answer very well and with little friction. Engines are usually carefully made, but it is very doubtful if the great mass of carriages and waggons are so. In the construction it is important that the axles should be parallel to each other, that they should be at right angles to the line of traction, and that the wheels should be in the same plane. But if the axles be not at right angles to the line of traction, or not parallel to each other, or the wheels be not in the same plane, the result will be a constant sledging and grinding away of rails and flanges, and risk of getting off the line, even on a straight line, cases having been known of railway waggons that required engine power to draw them down an incline of one in seventy-five.

Some agitation has lately been made by the medical profession on the subject of peculiar diseases arising to nervous patients from frequent and regular railway travelling. Railway officials generally deny the fact, but, like Galileo's movement of the earth, the fact continues to exist. There is a hard and almost continuous vibration. But let us proceed logically. If the two ends of a roller of equal diameter are moving over two paths of dif-

ferent lengths by reason of curvatures, it is obvious that if one end rolls the other must slide. Now sliding can be performed without vibration, if rollers in the shape of oil be interposed between the moving and stationary surfaces, or rollers of water as in the case of skating or sledging over ice or snow. But let the apex of an iron wedge be drawn over an iron surface heavily loaded, without the interposition of grease or other rollers, the result will be an intense vibration. We have an analogy in the volume of sound induced, by drawing a tension string of horsehair over the tension strings of a violin. What causes the sound? Simply the friction induced by the powdered rosin applied to the horsehair, which causes a constant saltatory vibration. To verify this fact it is only needed to rub the horsehair with a tallow candle or pomatum, when the vibration and sound will disappear. The grease supplies a series of infinitesimal rollers between the interlocking surfaces. Precisely akin to this is the movement of railway wheels on rails. A sceptic, rolling a railway roller or so-called pair of wheels on rails at a mile an hour may not detect a sound, but let the same wheels be loaded and put into a train at speed, they change from the condition of a river

running in a very tortuous channel at two miles per hour to that of the same river increased in volume and running at the rate of ten, when it cuts through the lateral river bends. When the friction takes place with one wheel grinding along a rail there is a great torsion of the axle, which becomes a spring to a certain extent, acting with a mischievous vibration and striking a succession of small blows tending to crystallise and disintegrate the metal. It is this peculiar vibration which is the characteristic of railway travelling—hard heavy wheels beating on hard rails, which constitutes the difference between rail and road, the latter being an unvibrating medium which absorbs the blows, while the wheels revolving independently do not create the same class of vibrations.

If the railway wheels be made to revolve independently of each other a large source of vibration will be at once removed.

The next consideration is the springs for bearing the load. The object of springs is to equalise the pressure of the wheels on the rails. If the springs be too hard the wheels will jump at inequalities with a force proportioned to the speed and the depth of the holes in sinking. The springs should act with great quickness

and as nearly as possible to the blow, and in the direction of the blow. It ought not to be a very difficult thing to spring an engine effectually, because the load is always the same, but so long as the butt of the spring is applied to receive the force of the blow, and the enormous friction remains between the spring-plates, the relief cannot be as quick as the blow, and if it is not, the spring is valueless. The bundle of steel plates ordinarily used are merely the external semblance of springs without the reality, and the rail has to supply the yielding which the spring is inadequate to. Till this shall be done, the engine will act as a destructive mangle to the permanent way. It is of no use to shirk this paramount question and talk of difficulties; if efficient springs cannot be applied to the engines as at present constructed, the engines must be built on a different pattern to accommodate the springs. No way or rails can be permanent, no traction can be at the minimum cost, till this be accomplished. How to construct the springs may require great consideration, but it must be accomplished ere the general source of accidents will be removed. The driving wheels alone in an engine weigh from three to four tons dead weight without any spring what-

ever, and a four ton hammer at a speed of forty to fifty miles per hour is a serious evil.

The tender, with its varying load, requires a peculiar construction of springs to be equally easy, with and without, its water and coke. First-class carriages, with a very small load, are comparatively easy to deal with as regards their effects on the rails, having but a very small load, but they are yet very far from what they should be as vehicles for passengers paying a high price for transit. Second and third class need springs for varying loads, and so do waggons, for they are full and empty at different times. It is less hard upon the rails to bear loaded waggons, which cause the springs to play, and so keep the wheels in contact, than to have empty waggons jumping up and down on the rails and occasionally jumping off.

One difficulty in springing is the top-heaviness of the vehicles. A carriage 8 feet wide and 20 feet long stands on a base of four wheels 5 feet by 10. If easy floating springs are applied, the vehicle will oscillate, and so springs that spring not, are applied. The form and structure of the vehicles must be considered before the springing can be perfect. If any one deems this criticism imaginary let

him stand on a railway over-bridge and notice the sinuous motion of a goods or coal train, in which all the vehicles are drawn by loose connexions.

The reason of this loose connection, unlike the tight coupling of passenger trains, is the difficulty of starting into motion with a close-coupled waggon-train with wheels and springs badly constructed and out of order. With the loose connexion the driver, in starting, first backs all the waggons together; he then moves the first waggon easily, and then the second, and so on through the whole train. When the momentum is obtained the motion is easily kept up.

The lubrication of the axle-journals is also an important matter. The common mode of using soap, *i.e.* palm-oil and alkali—useful in hot weather—is very defective in frosty weather, for it takes great power to move it, and heat is absolutely necessary to keep it fluid. Now heat destroys the lubricating material, but it appears that if oil be used and kept cold by means of water it is very durable. The heat generated by the friction is carried off by the water precisely as the furnace heat is carried off by the water inside a boiler, leaving the metal undamaged. Axle-boxes should, therefore, be provided with an ample

supply of water with oil floating on the surface, and thus all dirt will sink down.

In ordinary wheels the blow goes direct to the axle without any spring intervention. To obviate this defect the writer has applied tires with a spring between the tire and wheel, which is found to have the effect of rendering the tire more durable as well as safer, while it may be applied without tightness, so as to have the effect of a loose wheel, and of course the result must be favourable in preventing the twisting of the axle. And this kind of arrangement may be applied advantageously to engines with four driving-wheels coupled so as to compensate for irregular rails, and for the softness of some of the tires which wear faster than others, as the wheels can slip to accommodate each other inside the tires without grinding on the rails.

These spring-tired wheels have been tested on three lines of railway.

On the North London a set of solid wrought-iron disc wheels, the most destructive of all wheels to tires, by reason of their rigidity, were fitted with these spring tires, and, after running a distance of 106,143 miles, may now be seen in the International Exhibition in perfectly good working condition, never having been turned up. On the St. Helen's, Lancashire, a

set of six spring wheels have run on an engine 40,700 miles, and are still "perfectly good." On the Eastern Counties, a pair of leading wheels applied to an engine have run on sharp curves 34,000 miles, the ordinary distance with the same class of tires on the same curves, but applied without springs, being 14,000 miles.

What saves the tire must save the wheel also, and there is no doubt that this principle, largely applied, would at least double the duration both of tires and rails.

Passenger trains are closely connected by screw couplings compressing the buffer springs. This adds very considerably to the resistance by lateral friction. But, if loosely connected, the separate carriages oscillate and annoy the passengers, the wheels tending to move laterally and sinuously, as the waggons do, to seek the path of least friction. The closer the train is coupled together the more it resembles a long sledge. The true plan to obviate this difficulty would be to construct each carriage so as to run steadily, and there would be no difficulty in accomplishing this with a considerable saving in haulage power, and the advantage of a longer collapse of the train in case of collision. The shorter the train in proportion to its width the easier it

will run, and therefore it is desirable to make the carriages wide, which does not necessarily increase the gauge of rails, as with a sufficient length of carriage steadiness can be ensured, though the sides overhang the rail base.

Collisions occur chiefly by a rapid succession of trains running at different rates of speed. However carefully the power of the engines may be set out, various circumstances occur to change the conditions. Rails may be dry or greasy, clean or dirty, up or down inclines; a boiler may be dirty, or a tube may burst, or extra vehicles put on may overpower the engine. Then, if a train should be retarded, the following train may dash into it. If the power of collapse be through a long space, the evil may be moderated; and if the impending collision be seen in time and there be a sufficiency of break power, it may be arrested. But the practice of putting a break van in front and at the end of a long train to concentrate retardation in two vehicles is not the best mode. Every vehicle should have its separate break, either converting it into a sledge when required, or inducing friction on the wheels without damaging them. The practice on some lines of communicating by telegraph from station to station the arrival of one train before suffering another to

start, is, no doubt, very safe; but must involve delay, and it will not provide for every possibility of a train projecting over a crossing or siding.

With regard to safety or danger-signals, there seems to be only one sure method, viz. to keep the danger signal always up, changing for safety as a permission to pass. If there be any mistake on the part of the signalman in omitting to show the safety-signal, the utmost difficulty involved is the retardation of a train; but if he omits to show the danger-signal, an accident may take place more or less serious.

To sum up. The chief source of destruction to way and moving vehicles is to be found in the fact of bad construction, and especially of imperfect wheels and springs, and of enormous unnecessary dead weight. On roads the practice has always been to keep the weights as light as possible, because horses break their wind; but on railroads steam does not break its wind, but only breaks rails and tires.

With the exception of increased weight, scarcely any alteration has taken place in the construction of railways and wheels since the time of George Stephenson. The principal alteration on railways as regards safety mechanism has been the introduction of the fish joint by the writer, but even that is injudi-

ciously used and much more costly than is needed, and less efficient than it might be.*

It may seem strange that improvements are not made, but there is nothing surprising in it. Boards of Directors put all the responsibility on their officers, who are by no means overpaid, of making improvements requiring great care in experimenting, and innovations are rarely made in any branch of art by those engaged in its daily pursuit. It is the bystander who looks on and sees the defects and invents or contrives remedies which he brings before boards. If the engineer of the line wishes for a quiet life he will content himself with things as they are, and being no worse than his neighbours. If he adopts any improvement and it turns out a failure, want of judgment well be attributed to him; if it be a success the inventor gets all the repute from those who cannot reflect that good judgment is as important a quality as good invention, the recogniser as essential to progress as the discoverer.

Experiments are denounced as a source of

* "Brackets," suspending the rails by the upper table instead of supporting them on the lower table, are now largely superseding fishes and chairs, both as joints and intermediates, rendering the double-headed rail really reversible, and considerably reducing the first cost of materials both in rails and fastenings.

expense, yet it is quite certain that the want of experiments is the foundation of waste. But then it is argued, "experiments are of no use unless pursued through a great number of years." An engineer will assert that ten years are needed to prove anything in permanent way. Now this is a plain fallacy. The test of a permanent way is in the weight of the engine and the number of miles run over it. It would be perfectly practicable therefore to lay down a mile and move a heavy engine incessantly over it, and thus find out all its defects, and it might be varied in construction till the defects were remedied. So also experiments on wheels might be tried to test their breaking strain, and springs might be kept incessantly plying under a stationary engine, and in short every mechanical condition could be ascertained with as much certainty, as the consumption of coals by an engine in a factory or a steam-boat. If the railways were the property of private contractors who held them as an investment, it would not be long before their shrewdness would apply remedies to the evils which diminish revenue by waste, and by the destruction of human life.

The writer has satisfied himself that it is quite a practicable thing to construct engines

equal in power to any that run, perfectly safe against any accidents arising between wheel and rail, and free from damage to the road. It is also practicable, with a lessened amount of dead weight, to construct carriages and waggons free from vibration, noise, or oscillation. This condition of things will obtain with the advent of passenger railways for greater speeds without the impediments of slow goods trains.

There is a class of accidents on railways belonging wholly to the moving power, the boiler, which, under certain circumstances, may explode. It is desirable for the sake of economy to work at the highest possible pressure, and it is quite practicable to make the external shell of both boiler and fire-box so strong as to be unburstable. But the contingencies arise from wear in the process of use. An important point has hitherto been overlooked in practice. The boiler is valuable as a source of power in proportion to the quantity of fuel it can consume usefully, *i.e.* without waste. The smaller the boiler, and the greater the amount of fuel burnt, the greater the economy. But the fuel is rendered available by the agency of water converted into steam. If the water be impure, sediment accumulates, the free passage of the heat is impeded, and the metal of the

boiler is burnt away, the more especially if the fuel be also impure, abounding in sulphur. Distilled water, or rain water, is more rapidly converted into steam than impure water, *i.e.* with less fuel, and if any action takes place on iron analogous to that upon lead by the use of distilled water, the resources of chemistry should be brought to bear.

In firing a locomotive engine it would be desirable not to open the fire-door at all till the conclusion of the journey. In the use of coke or coal the opening of the door cannot well be avoided to raise and lower the fire. In descending a gradient of one or two hundred no fire at all is needed; in ascending the same gradient a very strong fire is needed. The best steam-producing fire is flame, and, if oil were not too dear, oil thrown on incandescent coke would be the best arrangement. There is now an oil to be procured that will ultimately be as cheap as coal in proportion to the heat developed, the American rock oil, the danger of which would be entirely avoided by dripping it from a closed boiler into the fire. In this mode the fire might be increased or wholly cut off at pleasure, and the production of steam regulated as neatly as the flame of a lamp by the turning of a screw.

CHAPTER VIII.

EXCLUSIVE PASSENGER LINES—NEW FORMED LINES.

PASSENGER AND GOODS TRAINS—EXPRESSES—SPEEDS—EXCLUSIVE PASSENGER LINES—DATUM OF STRUCTURE FOR PASSENGER VEHICLES—IMPERFECT STRUCTURE SOURCE OF ILL HEALTH TO TRAVELLERS—COST OF EXCLUSIVE PASSENGER LINE NOT NECESSARILY EXCESSIVE — LONDON AND LIVERPOOL — CALAIS AND TOULON—LONDON AND CADIZ TO PANAMA—RAILWAYS NATIONAL GAIN—MODES OF INCREASING PROFITS—RAILWAYS COMBINED WITH RENT-ROLLS FROM BUILDINGS—LEGAL DISABILITIES OF RAILWAYS.

In the present condition of traffic on the great metropolitan railways accidents involving loss of life must infallibly be on the increase, whatever may be done in mechanical improvement respecting them. Express trains run—not regarding mere departures and arrivals—at a speed of upwards of fifty miles per hour, and goods' trains run at speeds of twenty miles per hour, frequently dwindling to less by overloading, and these trains are shunted for hours, and business impeded, in order to

get out of the way of the express trains. Now, it would be a great advantage, in a pecuniary point of view, if the express trains were abolished, for the accidents would be lessened as well as the cost.

But there are a constantly increasing number of people to whom time is valuable, and to whom expense is comparatively no object, and they will not abate a jot of the highest speed that can be attained if they can get it. A speed of from fifty to sixty miles per hour can be attained with perfect safety and with no excessive cost if only a clear and well-conducted line and well-constructed trains be used. In short, the lines must be passenger lines and not goods' lines. Goods do not pay well except in heavy trains drawn by heavy engines, and at comparatively slow speeds, and if passengers are to travel on goods lines they should travel at the same rates of speed in order to ensure safety. Duplicating the main lines will not get over the difficulty, by keeping the fast trains to one pair of lines and the slow to the other pair. Goods need warehouses, and sidings, and crossings, and a great number of porters, and whether the passenger lines be side lines or central, the goods lines will interfere with the traffic.

Passenger trains actually travel at speeds of from fifty to sixty miles per hour on rails in inferior condition. This rate involves considerable risk from bad joints and from collision with other trains travelling at lesser rates of speed. If light engines and light trains were used with corresponding rails in thorough order, and with no impeding traffic, these rates of speed might be maintained without any risk and without any immediate evil. But it would not do to permit any heavy destructive goods traffic on such lines. If light goods were permitted during the night the engines and waggons should be equally well constructed with the passenger trains, with no greater load per wheel, and with less speed.

But would it pay to have distinct passenger lines of great speed?

That must depend upon the wealth or commercial importance of the district. If the expenditure in law were light, and the land could be hired at a rental of its agricultural value for a lease of nine hundred and ninety-nine years, lines of double way might be constructed for fast light trains at the rate of 10,000*l.* to 15,000*l.* per mile, including locomotives and rolling stock of the best quality.

The convenience of humanity would be studied as the datum line for the construction of the carriages; they would be lofty enough to permit standing upright; they would be ten feet in width, with a central passage-way to permit the guard to pass from one end of the train to the other, thus getting rid of the great difficulty of want of communication between guard and driver. On either side the passage would be enclosed cabins or apartments for four persons each, for passengers wishing to be private, and open saloons would be provided for the gregariously disposed. The seats of each passenger should be arranged to fold up against the partition, so that each passenger might sit or stand at pleasure, an important consideration to ensure free circulation of the blood. Arrangements would be made to provide tea and coffee, and similar refreshments while travelling, and also for efficient warming, ventilation, and lighting, and by fitting construction easy movement without vibration or oscillation would enable the traveller to read or write at pleasure. In this mode a constant speed of from fifty to sixty miles per hour could be maintained without the necessity of the traveller alighting, or injuring his health by vibration of the brain or

nerves or of the digestive organs, or by swallowing food in too great a hurry or at too distant intervals of time.

It may be remembered that on the opening of the Brighton line, many wealthy persons took season tickets with the intention of living at Brighton, and travelling backwards and forwards daily. But it was found that they could not persevere in it as it affected their health, and they were unfitted for their work after the journey. Now, it is quite clear that a man would not be unfitted for his work by sitting on a sofa at home for an hour or an hour and a half, nor by sitting in a good atmosphere; therefore, either the carriages must have been badly ventilated, or the vibration of the wheels on the rails was not sufficiently intercepted by efficient springs, and had the passengers been obliged to ride on the engines they would have been half killed. The sitting posture, which induces paralysis in literary men, possibly by the compression of their blood-vessels and retardation of the circulation which induces cold feet, must be much exaggerated by the incessant vibration of a carriage. The engine vibration in a steamboat is far less favourable to health than the soft easy motion of a sailing-vessel.

If we assume a line 100 miles in length, and the cost of it to be 1,500,000*l.* per annum, that would require, say 75,000*l.* per annum to pay interest at 5 per cent., or say 206*l.* per diem. Assume maintenance at 10,000*l.* per annum, that would be 28*l.* per diem; total, 234*l.* The working expense of trains would be say 15*l.* each, going and returning a distance of 200 miles, with accommodation for say 150 passengers each train. Four trains each way, with 75 passengers in each, or half full, at 1*l.* per head for the 200 miles, or about 1¼d. per mile, would maintain the line and pay 5 per cent. A very small staff and outlay in maintenance of way and rolling stock would suffice for such lines.

Thus, supposing land at its agricultural value, and law and Government expenses *nil*, a high-speed railway might be made between London and Liverpool for 3,000,000*l.* Four high-speed trains, with seventy-five passengers each, going and returning the whole distance, at 2*l.* per head, say four hundred miles, at 1¼d. per mile, would pay all expenses, and give 5 per cent to the shareholders, and the passengers might go and return the same day within twelve hours, giving an interval of four hours to business, and all this without any hard

work on their bodies to affect their health. And the interior passages in the carriages would permit of walking exercises and fresh air on end galleries between the carriages. In short, could any arrangement be made for hiring the land it would be possible for two thousand annual subscribers to maintain a subscription line, at an annual cost of 100*l.* each, or fifty double journeys; they could maintain such a line for their own use, and accommodate thirteen friends each per week with tickets gratis. Are there two thousand manufacturers and merchants in London and Liverpool, with the aid of Manchester, to do this thing?

The distance from Calais to Toulon is six hundred miles, or thereabouts, and the probable cost of a railway promoted by Government, and the rails and materials furnished from England, without duty, would be about seven millions and a quarter. Four high-speed trains per diem each way, or eight trains, with ninety-five passengers each, at 2*l.* 10*s.* each way, or 1*d.* per head, would clear all expenses and give 5 per cent to the shareholders. And the journey from Calais to Toulon might be performed in less than fourteen hours.

Whether this is worth doing now—whether England and France have advanced sufficiently far in civilisation, and wealth, and the value of time—whether it is worth while to bring Madrid within fifteen hours of Paris and twenty-three hours from London, and Cadiz within thirty hours from London, and thus materially diminish the sea-distance to Panama as the highway to Australia—whether it is worth while to bring the orange-groves and balmy atmosphere of southern France within eighteen hours of London now, is simply a question as to the number of the wealthy who may desire it; but that this will eventually come to pass is no mere problem; it is as sure a thing, sooner or later, as the transit between London and Windsor, or Paris and Marseilles.

At present the question is, are there wealthy capitalists enough in Europe to furnish eight millions and a half of money to shorten the distance between London and Toulon to a day's journey, and seven millions more to bring Cadiz within thirty hours of London, and travellers enough to pay interest and expenses for special travelling, at from forty to fifty miles per hour, at 1d. per mile? Are there, moreover, men with political power

sufficient to overcome commercial hesitation, and willing to write their names on this new scroll of the world's civilisation, rendering distance no bar to the personal communication of the powerful and intelligent throughout Europe.

No, not yet! Europe is not yet ruled by men loving freedom and man's happiness, and using power for the furtherance of freedom, and so all surplus industry is wasted on soldiers and the materials of war, instead of being vested in reproductive works.

The existing main lines, as well as their branches, are yet far from being developed to their full extent. They have created a large goods traffic, and they are not mere lines of distant communication from Liverpool, Manchester, York, Glasgow, and Edinburgh, to London, but they are lines of communication between neighbouring towns and cities, links of a general chain of communication for the transit of goods and passengers, at moderate speeds of twenty to twenty-five miles per hour.

Notwithstanding their host of imperfections, there can be no doubt that railways have produced an enormous national gain. The accumulated English capital that lies idle, seeking

for employment all over the world, is proof of this. The public have benefited if not the shareholders; and the railway managers, finding their returns insufficient to pay the expense of large trains and heavy engines, endeavour to stimulate traffic by low fares and excursion trains, when the earlier transit of curiosity abates. But a general lowering of fares means, notwithstanding, if rightly managed, a general increase of travelling, otherwise the rail will not pay, especially with the competition of constantly increasing lines.

Comparing the general aspect of the highways and turnpikes with that of the railways, the difference runs as follows. The former have gone with the stream of population along their whole course, the latter only at some few of their stations. A highway may grow into a street, just as the main thoroughfares of London, from being formerly called roads, have now changed into streets by the advent of houses along their border; but a railway cannot do this so long as it shall labour under its present disabilities.

What are those disabilities? First, the feud that exists between the owners of railways and the owners of land—the border chiefs along these lines—an Esau strife that arrests pro-

gress. In the olden time the lords of the land were the reiver barons, who levied black mail on all those travelling by land or by water. In the modern time the lords of the rail levy —not black mail, but mail fares, or express fares, at their own pleasure, up to Act of Parliament limit. They do not, it is true, for the most part, go to this limit, because they cannot. There is a limit to the paying power of the public. But they have the power to raise fares, or alter fares, or take off trains, or alter train-times at their own will and pleasure, and also to open or close stations, or vex people with by-laws; and while they keep to themselves the power to do these things, people will not build on their borders, will not make streets of their lines, will not put their heads into the lion's mouth roar he never so gently. Were it optional to the street paviours to raise a toll-bar in Regent-street, not long would it be a street of magnificent shops. Houses are not built on land without freehold or leasehold security. The owners of railways, who would draw population to their borders, will have to admit that population to a voice in their council, or the borderers will have to buy up the railway and work it for their own convenience, even as a parish road, or they will have to

make a new rail of their own. Otherwise any rail-owners—supposing no competition—would hold the surrounding population at their mercy; they would be, practically, an irresponsible body, and consequently tyrannical. The difference of value in property, inside and outside of the toll-bars that cramp London, is proof of this.

And now to turn to the other side of the question. The rail-owners are forbidden by the Legislature to be the owners of land, or buildings, or property, other than for the purposes of transit. They may not, as a corporate body, buy land and work it, or let it and build upon it. By the terms of the Legislature they are forbidden to reap a profit by any other means than trains, transporting the public and their goods. It is true that the Legislature grants them power to take compulsory possession of private property, but only for the public service; and there is apparent justice in this. But it seems difficult to understand the utility of precluding them from voluntary purchase and sale along their line. If an owner of land wishes to convert it into a building property, the first thing he does is to cut roads through it. It is comparatively valueless till this be done. And he

must construct sewers, and procure to be laid down water-pipes and gas-pipes, and get an omnibus or stage-coach to run on it, and then his houses will be habitable, according to modern notions of the necessities of human life. And he does not think of putting a toll-bar on his road. He avoids that if he can, for he knows that it would naturally lessen the value of his rents.

Now let us imagine a railway constructed on this principle, with sewage-pipes, water-pipes, gas-pipes, and stopping places every quarter mile distance, and the whole belonging to and under the control of the residents along the line. In such case the fares would be kept down to mere working expenses, the trains would be light and numerous, to serve as conveniently as omnibuses, and the working expenses would be reduced to the minimum, by the employment of machinery—not at the lowest nominal cost, but of the really cheapest kind for efficiency. The railway itself would be of the most perfect structure, and the rolling stock would not slide or sledge, but really roll, so as to involve the minimum of friction, and the smallest amount of destructive wear, both of rails and machinery, as well as substructure. At each terminus of this railway would grow

up a bazaar, or market, where the produce of farms and factories along the lines would be sold, with the minimum of human labour in transit. These two termini would, in fact, become towns, united by a railway street; and, moreover, towns such as towns should be, and not as towns are. The sewage and factory waste would feed the farms, the rails would communicate with the factories and farm-yards, the factory workers and farm workers would amalgamate, and take to either process at different times and seasons, with immense advantage to their moral and physical health, and with great expansion of their intellectual faculties. Coals would be cheaply carried on to the farms, and then power moved machinery would increase, and the labour-saving processes used in the manufacture of clothing and other things, and in metal and other works, would be the every-day practice of the manufacture of food.

Supposing all this planned with purpose aforethought, instead of mere haphazard contrivances, as population thickened, at one or other of the termini a church would be built, a chapel, or both, or many; a theatre, a concert-room, or lecture-room would follow. Trains at all hours, and special trains for

congregations and audiences, would be matters of course.

And the buildings, the factories, the dwellings, what would they be like? Could the dwellings possibly, in the full view of all other improvements, remain such as we see them in existing towns? A wretched damp ground floor below, generating that specific class of evils called servant's disorders, and a receptacle for soot and foul air above, called a "cock-loft;" a third of the space wasted in a staircase, full of draughts and cold rheumatic currents; and, when dried and warmed to a healthy condition, fitted for human beings, perilous to dwell in by reason of its combustibility, and with arrangements all so unmechanical as to involve twenty times the needful labour on every operation that is required for analogous operations in a factory. Surely such things could not go on. The mere comparison of cost, in the absence of common sense, would determine the question.

A villa residence, situated on its own grounds, and not overlooked, is doubtless a very pleasant arrangement, and especially to the Teutonic mind, but in a rich and thickly-peopled country this is a costly luxury, belonging only to the rich, and the writer is far from

wishing to decry it. In the outskirts of cities there is an attempt to imitate this by "detached" and "semi-detached" cottages, with gardens enclosed by walls, in which vegetation stagnates in an air pond, just as weeds grow in a stagnant water pond. Streets composed of brick walls, with holes in them for doors and windows, supply the great mass of the community, not quite so hideous but quite as monotonous in Belgravia as in Harley-street, and whole rows of wretched four-roomed cottages, on damp and badly-drained ground, supply the shelter wants of London work-people.

In spite of this general indication of a desire for isolation, most human beings are gregarious. They do not like to live in badly-arranged lodgings, subject to inconvenience and quarrels, and so they take a small house, which they can share with lodgers of their own selection, instead of going to a large lodging, where incongruous people are mixed up together. Some people are of isolated habits, but much of the love of isolation arises from refined temperament that cannot endure the coarseness more common amongst the gregarious. Mostly those of least wealth, or those in poverty, lack the appliances that beget re-

finement, but this will grow better as time wears on. The writer, in the year 1830, was one of the first to draw attention, in the *Mechanics' Magazine*, to the fact that the working classes were badly lodged, and that it was possible to lodge them better, with a profit, in an article entitled "Better Housing the Working Classes." In this year 1862 many model lodging-houses exist, and people have become aware that it is quite possible for large houses to be built cheaper than small ones, and so arranged and divided, while provided with every convenience, that greater isolation of separate families may be obtained than with four-roomed cottages, that large buildings do not necessarily require dwelling in common, and that the occasional isolation essential to the well-being of cultivated minds can be had in the large and economical, as well as in the small and expensive building. A man may be isolated in the private dwelling of a street, and so may he be in the private chambers of an inn if he be well disposed. What can be more isolated than the chambers of law students, where hundreds are gathered under one roof?

Lord Shaftesbury has been a very useful worker in showing what can be done in im-

proving the lodgings of the working classes, but it was the stitching machine that practically remedied the evils of the real sempstresses, overwhelmed by the mock sempstresses, who flocked to that employment because the whole capital required was the possession of a needle. But Lord Shaftesbury is wrong in trying to keep up the dens of London to the exclusion of railways, instead of providing model lodging-houses along the lines of railway. But his agitation will produce this more desirable result.

Although these arrangements have been described as practicable on new lines of railway yet to be made, when some clear-brained landholder shall see his pecuniary interest aright, and be to the railway maker what the Duke of Bridgewater was to the canal maker, Brindley, —although the landholder shall survey his estate and do this thing, and shall set a pattern for the world to follow, multiplying his own revenue while being the world's benefactor, still there seems to be no insurmountable difficulty in applying the system to existing lines. On main lines, with frequent fast traffic, there may be a difficulty from risk of collision with frequent stopping trains, nor could this difficulty be obviated by a third line of rails

especially kept for the slow and frequent traffic. And to obviate this many of the existing lines must ultimately come to moderate speed; or probably the landholders will make single lines themselves, for it is not possible to suppose that many years can elapse leaving the rail-coast a desert as at present. But there seems no reason why many of the branch lines should not be rendered thus available.

CHAPTER IX.

SUPPLEMENTARY RAILS ON HIGHWAYS AND TURNPIKE ROADS.

HIGHWAYS AND TURNPIKES OUT OF USE—CAN THEY BE CONVERTED INTO SUPPLEMENTARY RAILWAYS—STEAM ON HIGHWAYS—OBJECTIONS—LIGHT ENGINES—RAILS SAFER THAN ROADS FROM ACCIDENTS—IMPROVEMENTS IN AGRICULTURE WILL FOLLOW THE RAIL—BETTER STORAGE OF PRODUCTS—MANURING THE EARTH ARTIFICIALLY FOR INCREASING CROPS OF VEGETABLES.

When we look over the map of England, and behold how very small is the amount of railway mileage compared with the mileage of turnpike-roads and other highways, we naturally ask, must these roads and all the property bordering them be for ever doomed to stagnation, be condemned to a transit analogous to that of Chinese junks for slowness, and without the economy of railway transit? There is no valid reason, nothing to prevent

their almost immediate conversion into practical railways over almost their whole mileage, provided only that the landholders and the inhabitants of unrailroaded towns and villages will awake from their slumber.

Objectors will cry out that it cannot be, that the outlay is too great, from 10,000*l.* to 50,000*l.* per mile. This has been, but need not be again. There are twenty-two thousand miles of turnpike-road in England and Wales. What they have cost to make is beside the question; there they are, and 8,000,000*l.* have been borrowed on them on mortgage, and their interest is in arrear. And little as is the work done upon them, their annual maintenance costs 33*l.* per mile. Are these roads, and the many more miles of highway and parish and farm-roads connected with them, and all the property they lead to, to lie comparatively waste, or to continue to be worked at a cost ten times that of railway highways by steam, or shall they be made into practicable railways wherever steam may do the work of horses at a cheaper rate.

Upon the solution of this question depends the practicability of placing the progress of agriculture side by side with that of manufactories in the districts still unoccupied by

railways. Haulage on to the land and haulage off is the great daily cost to farmers. Without cheap transit into their very farmyards they cannot have cheap coal—at least in the south—and without cheap coal they cannot have steam-engines or machinery. Without machinery farmers cannot make good profits, or their landlords obtain large rents. In the general question of physical progress our chemists are in arrear of our machinists. In agricultural questions they are in advance of our machinists.

Thirty years ago there was a strong public excitement in favour of steam-carriages on highways and turnpike-roads. Townspeople, villagers, innkeepers, landlords, road trustees, all were opposed to them. It was said they would frighten horses, would blow up, would not go up hill, would overturn themselves down hill, and many other things. But they went on. Walter Hancock ran his steam-carriage as an omnibus for four months, many times daily, between Paddington and the Bank. He climbed the hill of Pentonville, with the most execrable of all roads below him, and he descended it, and he did not frighten horses, and he did not blow up. On the subject of frightening horses there seems

to be an unreasonable impression. To begin, horses belong to the few, steam belongs to the many. Horses will bear, when trained, the firing of cannon, therefore they can be trained to bear the hissing of steam. And the many have a right to say; "The engine is docile, submits to guidance; let the horses make way for the engine till they cease to be self-willed. A shying horse is a wild creature, and a dangerous one, and the owner ought not to bring him into public thoroughfares till he becomes a civilised and not a wild horse."

The highway locomotists accomplished much, but rarely did they succeed in getting good workmanship into their engines, still less a good plan. And, worse than all, they had only a yielding, rough, and jolting road for their propelling fulcrum; this would ultimately have been amended, but the worst and final blow at the time was the advent of railways.

The railways were made with edge rails above the surface of the ground, and that, saying nothing of the speed, seemed a conclusive reason against any attempt to lay down rails whereon to apply steam on the turnpikes. Indeed, the spirit of imitation is so strong in humanity, that established forms remain long

after their utility has departed. A strong illustration of this propensity to abnegate reason in favour of custom is found in the message of the American farmer's wife to her neighbour: "Be so good as to lend me the loan of your meat-axe to make our hog and hen-coop." Even then steam-coaches on the road were made to assume the form of horse-drawn stages, and on the railway to this day a carriage is scarcely constructed first class without fictitious curved lines on its panels, pretending to be structural where there is no structure. Thus the possibility of making the turnpike road serve two purposes seems never to have occurred. Yet all that is required, mechanically, is to insert efficient rails or trams on the surface of the roads *at the same level.* By this mode any kind of vehicle may cross and recross the road without impediment.

The objections will be:

First, cost. Answer, 1500*l.* to 2000*l.* per mile would pay all the cost, steam-carriages and waggons inclusive. Mere farm rails about 500*l.* per mile.

Secondly, frightening horses. This difficulty has been before disposed of.

Thirdly, difficulty of mounting hills. An-

swer. The Birmingham and Gloucester Railway has a three-mile hill of one in thirty-seven, which has been worked for many years with very heavy machinery. And the ruling gradient of the turnpike-road is one in thirty. Practicable light engines can be made to surmount this with a load behind of sixteen tons, say one hundred and fifty passengers. The same engines may travel twenty-five miles per hour on the level, and at a reduced pace take one hundred tons of goods and engines behind it.

Fourthly, accidents from speed. Answer, it is not necessary to run more than stage-coach speed, and an engine would be quite as amenable to control in stopping and starting.

Fifthly, the difficulty of passing through towns and streets. This depends entirely on the class of rail or tram laid down, and on the kind of engines and carriages used. The engines and carriages used on ordinary railways, with their requirements of turn-tables, and points, and crossings, would not answer, nor does it follow that it would always be desirable to use the main streets of a town for the rails or trams. But there is less risk from vehicles that follow a particular track than from those which cross diagonally over a road; children and pas-

sengers can easily avoid the definite rail, but not so easily the indefinite track of the ordinary carriage. The driver of a self-guided machine has only to increase or diminish his speed; when he has to steer the machine also the risk is greater.

Landlords, townspeople, villagers, innkeepers, farmers, and others are all interested in bringing this thing about. The turnpike bondholders are also interested in it. Are not the trustees, secretaries, clerks, and surveyors, also interested in it? At first sight it may seem otherwise, for they get by no means large stipends, and why should they trouble themselves to increase their work?

The reason seems plain. If the roads earn more money, higher salaries and wages can be afforded. No man can thrive so well by poor customers as by wealthy ones. The fund for paying increased salaries would come out of the savings in repairs and maintenance, for rails, under light machines, would neither deflect nor abrade.

It is not proposed to do all at once that which will follow in succession, the application of rails to twenty-two thousand miles of highway, at a cost of fifty millions; involving an amount probably equal to a whole year's

surplus profits of the whole community. But let us imagine the results that would gradually be realised.

Light locomotives, not needing a legion of officers and machinists, but attended to each by its own captain, with an individual interest in its well-doing, would bring from the farms their produce of grain and dead meat—for no live meat ought to come to the town, poisoning it with the offal instead of leaving it on its own farm. Or they could bring what has never yet been brought, a sufficient stock of green vegetables to supply the consuming power of the towns, on to the main-line stations, or convey them on the railed highway to the market direct. They could be brought direct to the market from the very farm-yard, and light movable rails, for the purpose of horse transit, could carry manure on to the field and bring produce off it, from and to the farm-yard. The same engines can be arranged to work as stationary farm engines, by merely lifting the wheels a short distance from the rails, and connecting them by a belt to the thrashing machine, the turnip cutter, and the chaff cutter, or a small saw-bench and morticing machine to execute various wood or other work for farm purposes. With fitting ma-

chines, many of the farm labourers, with aptitude, would become carpenters, or turners, or engine fitters, after a little practice. And the engine might also be run on to the fields to pump water for irrigation.

Farm storage is as yet of a very imperfect kind. Grain is kept in stacks in the straw, or placed in granaries, which are usually rooms of bad construction, and in both cases it is exposed to rats, mice, weevils, and other vermin. Potatoes and other watery vegetables are stored almost haphazard. Fresh meat, for the food of farm labourers, is not common, owing to the difficulty of preserving it; and the practice of killing cattle on farms is retarded by the risk of spoiling in transit. With regard to grain, there would be no difficulty in constructing large cast-iron canisters, built of plates, like a gasometer, through which warm air might be pumped till it was quite dry, after which it might be hermetically sealed, to the exclusion of all vermin. A small opening at top would serve to fill it, and a draw-off pipe at bottom to empty it. And such granaries—which might be used, if required, to preserve a surplus stock, to be opened in years of famine—would be less costly than our ordinary granaries. Grain

might be thus preserved, without loss, not merely seven years, as in the Egyptian granaries of Joseph, but seventy times seven, like the "mummy wheat," possibly, from the tomb of Joseph, and which is still capable of germination by reason of the air having been excluded from it. In Southern America men store up grain in the skins of oxen, taken off entire and made into a hard dry bag, each of the shape of an ox. In Spain, and other countries, men dig a hole in the ground, called a *silo*, which they fill with grain and cover in. The outer grain germinates from the moisture of the ground, and then grows into a hard shell some inches thick, in which the inner grain is preserved for years, the interstices being filled with carbonic acid gas from the decomposed shell, which averts all further decomposition.

Fresh meat may be preserved by cutting thin, and drying into a kind of glue, in a rapid current of warm air. And it may also be preserved by putting it into close vessels with carbonic acid gas. In either case a more wholesome provision than salted meat.

With the facility of rails on the highways will come the large facility of coal transit; and it is possible that large improvements in agricul-

ture and gardening will come out of that. The growth of plants depends upon the supply of the food they need in the soil, but, more than all that, it depends upon *heat.* Where heat is not, vegetation ceases; and where heat is great, provided there be moisture also, there vegetation is most abundant. Sunlight is essential to the ripening of crops and the vitalising of seed, but we have proof enough in our hothouse crops of fruit and vegetables, that artificial heat may be made to play an important part. And gardeners recognise the fact that bottom heat, or heat under ground, is the most available. In the hothouse, occasional coolness is needed to produce the best results, and plants seem, in some respects, like human beings, desirous of keeping their feet, or roots, warm, and their heads, or leaves, cool. When steam-pipes run under ground, the roots of grape-vines and other plants will stretch out many feet in distance to get to the warmth. When coal-pits are on fire at a great depth under ground, snow will not lie and grass keeps green throughout winter. And one advantage in draining land and making it porous is, that the rain which falls through the surface leaves heat behind it.

From the refuse of gas works, wherein coal undergoes destructive distillation, manure for

land is now largely prepared. Coal thus contains manure and heat also. If we were to burn coal on the surface of garden land we should, probably, destroy its capacity for vegetable producing for a long time; but if we could burn the coal at a sufficient depth there would be a gradual permeation of heat to the surface and the roots of the plants, and the gases would ascend with the heat, supplying manure.

It is, therefore, probable that coal used in this mode, depositing the whole products of combustion under ground, would be the cheapest agricultural process, and that the artificial heat so supplied would induce crops of green vegetables through a longer portion of the year. The plan would be to lay a series of perforated pipes at a depth of from four to six feet under the surface, in a convoluted form, to burn the coal in a close furnace, and, if necessary, draw it through, by fan or other power. Sloping surfaces would be the best for this arrangement to facilitate draught, placing the fire below, as in an ordinary limekiln, and having the exit above. The slopes of railways might be largely turned to account in this process, which would also prevent slips, by affording thorough drainage.

CHAPTER X.

CITY EXTENSION BY RAILS.

UNITED STATES STREET LINES—DIFFICULTIES IN OLD CITIES—IMPROVED PAVEMENTS—GRANITE TRAMS—MECHANICAL QUESTION—INSUFFICIENT WIDTH OF STREETS—IMPROVED HORSE-SHOES FOR SMOOTH SURFACES—DOUBLING THE STREETS BY FORMING RAILS AT THE FIRST-FLOOR LEVEL—UNDERGROUND LINES NOT FITTED FOR PASSENGERS—USING THE STREETS FOR THE RAILS AND STOREHOUSES, AND MAKING AN UPPER STREET FOR PASSENGERS, WITH SHOPS AT THE FIRST-FLOOR LEVEL—IMPROVED ATMOSPHERE AND LIGHT—STRUCTURE OF RAILS IN STREETS—INCREASE OF DWELLINGS ON HILLS ROUND LONDON—GARDEN GROUNDS ON LOW LEVELS—IMPROVEMENT OF LONDON HUMANITY—STEAM LOCOMOTIVES ON COMMON ROADS DEFECTIVE FOR WANT OF MECHANICAL "MUSCLE."

IN the United States of America, when railways commenced, the roads were of a very inferior kind, both in town and country, and there was little difficulty in persuading the community to permit the rails to pass freely through towns, just stipulating that through the streets the engine should be unhooked, and horses substituted to draw the trains. Then

the engine was allowed to draw the train at a slow pace, and subsequently a bell was suspended from an overhead gibbet, to be rung by the passing train, as an automatic notice.

From this has grown up a system of street railways, on which large omnibuses are drawn by horses; and a practical monopoly of the street is given to the omnibus companies by the local government. It is easy to understand that any railway must be preferable to a very bad road, and assuredly it is less expensive to keep in repair a railway, than a road. These street railways usually are made to pass up one narrow street and down another, and they are not much interfered with by other traffic, though people do construct their vehicles to run on flat plates, forming a part of the rails. But it is obvious that if slow vehicles use the rails in advance of the omnibuses, all traffic must be ruled by the pace of these vehicles. If this annoyed the public, probably the slow vehicles would be driven away by Lynch law; and so the railway owners have a very profitable monopoly, not to be affected, unless the temper of the community were aroused by very bad management, or very excessive charges, or the intrusion of black men. The rail is, in short, the public road, and the consideration of

ordinary road vehicles is subordinated to the rail. No large amount of carriage keepers are affected by it. But Broadway, New York, where fashionable people resort, does not yet admit rails.

Many attempts have been made to introduce this system in English towns; and it has been assumed that because it answers in the United States it would answer here in London. The reasons alleged in its favour are, that large commodious carriages can be used, carrying many more persons, with less crowding and with less resistance, owing to the wheels running on iron rails.

There is no doubt that on a level road, with an iron surface, one horse will draw a given load as easily as four horses can, over a badly paved road. But this advantage has a very considerable drawback on inclines, and very little advantage on declines. And on the level, the omnibus which uses the paved road has a considerable compensation in the greater diameter of its wheels. And the omnibus on the paved road might have the paving so improved in structure, as for example, by using large granite trams, that it would run with little more friction than the iron wheels on the iron rails, though not so permanent. The rail car-

riage has the advantage of being self-guided, while the omnibus on the paved road must be guided by the horses under the control of the driver. But to set against this, the wheels of the rail carriage involve considerable lateral friction; and the ordinary omnibus on the paved road can move in any direction to make way for ordinary vehicles, or to get past them, while the rail omnibus can only move on its own rails, and is useless off them; and if the rails are dirty, the friction of the rail wheels is considerably increased, and the track on which the horses tread, between the rails, is more rapidly worn out, from their always treading on the same line.

If only one line of carriages is to be used along the street rail, it is evident that all must move at the pace of the slowest, and if they be railway carriages, with wheels only adapted to run on rails, they cannot pass each other unless duplicate rails be used to turn off. But this requires wide streets.

If, therefore, rails and railway carriages are to be used along a line of street with shops, the railway, either single or double, must be in the centre, and on either side must be a double space for carriages of the ordinary kind, one half for passengers, and the other half

for carriages to draw up at the doors. Therefore, a street of traffic with one central line of rails would require to be fifty feet in width, and with two lines of rails upwards of sixty feet.

Much talk has been made about the great advantage of dividing the traffic across London Bridge into four lines, two for fast and two for slow traffic, but it must be remembered that in this case there are no doorways for carriages to draw up in front of.

The conclusion arrived at is, that it is impracticable to form railways in narrow streets of great traffic. There would be no advantage, but a great disadvantage, in the rail carriage, in case of a block, as it would become a kind of island, immovable, till the other vehicles had passed round it; and if the street were narrow, it might so happen that the carriages would not be enabled to pass at all, and, therefore, if rails are to be used as they exist, the streets must be wholly given up to them, and denuded of ordinary vehicles, or the ordinary vehicles must be fitted with wheels to suit the railway. This would be difficult, seeing that there are some thirty different gauges of wheels in road vehicles.

It is no doubt very pleasant to have roomy

vehicles, provided there be space for them. And so, also, the more passengers the vehicle can carry, the more economically can they be carried. But the chief object sought for in laying down rails is to enable the passenger traffic to be carried at a more rapid rate. Along the main lines of traffic, omnibuses start every two minutes, or less, and they do not fill as a rule, *i.e.*, there are many empty seats. If, therefore, double-sized omnibuses were to run, they must take double time to gather the same number of passengers, or they would run with a larger amount of proportional dead weight. But passengers would not agree to wait, and would pass on, and, therefore, the only remedy would be to lower the fares, and so tap a lower stratum of passengers.

> "Let those ride now, who never rode before,
> And those who always rode now ride the more."

And thus the new riders would undergo a process of change, as the old ones have done. Some objections have been made about the difficulties to be incurred by breaking up the streets to repair gas and water pipes and sewers; but this must not be dwelt on, for the rail would have a manifold advantage in being enabled to span the openings without interrupting the traffic.

But we must deal with things as they are, and as the streets are not fitted for rails, let us inquire whether the street surfaces cannot be improved, so as to enable one horse to do the work of two.

In paving, a rough surface is studiously kept, in order that the horses' feet may keep a hold. It is doubtful if they slip more on wood pavement than on stones, but it is certain that if they slip on rough stones they take more damage than on wood. But the rough surfaces, intended to prevent horses from slipping, add very materially to the draught, and if the draught be reduced to a minimum, the chances of slipping would be lessened. The roughness of the road also involves another difficulty, the necessity of shoeing the horses with iron. On natural ground, and turf, the horses hoofs scarcely require shoeing, and it is probable that if the whole roads were paved with slabs of granite, of large size and smooth surface, improved shoes of leather or other material might be substituted for iron, without slipping. In this case the draught over the smooth granite surface would be quite as light as on the rails hitherto laid down, and the vehicles, better made and sprung than they now are, and moreover lighter, could traverse the narrow streets, and make way for each other

with perfect facility. For on such an improved road the weight of the vehicles might be reduced, and the noise reduced to a great extent; and there would be neither dust nor mud, no nuisance save the manure, which is the main source of slipping, and should be incessantly removed. And there is yet another thing. On a smooth granite surface, level, and not arched as on ordinary roads, steam traction could do its work perfectly.

But if it be desirable to lay down rails in the streets, and abstract from them all ordinary traffic, there is one practicable mode of accomplishing it. It has been many times proposed to erect an open cast-iron framing in the streets, and lay rails on it, running the trains at the level of the first-floor. But the effect of this would be to darken the shops and produce an unpleasant effect on the upper floor, saying nothing of the risk in case of getting off the rails, and the annoyance of the ashes from the fire-box.

The perception of this difficulty has brought forth the underground lines amongst the sewers, communicating with the termini of the different railways. When the North-London was first proposed it was as a direct line for the carriage of goods from Camden-town to the

Thames, but it was no sooner opened than it was discovered that it was essentially an omnibus line, connecting the various outskirts of the town together. The Tunnel lines are regarded as passenger lines, and especially as omnibus lines, but it is probable that their chief use will be as goods lines, and as communications for the end or beginning of long journeys. People think little of a tunnel a mile long in a journey of fifty miles, though even then they draw up the windows to exclude steam and gases. But possibly other smells may be found beneath the streets, and occasional leakage of the gas with which the tunnels will be lighted. No doubt the tunnels will answer the purpose of passengers at specific points, but they will scarcely be used by the morning and evening passengers who come and go from suburban dwellings to city offices. Many of these persons get no fresh air throughout the day, save in the morning or evening journey, and if they change the open air for the tunnel they will find it out by gradual deterioration of health. It is true that we have not yet got to the end of possibilities in the way of ventilation, and we may even warm tunnels; but as a rule the inhabitants of London, who may many of them

live, like the troglodytes in caves, all day long, lighted by gas, must try to get rid of their etiolation morning and evening, and that cannot well be done in an elongated cavern, however well the cavern be made to assume a Salvator Rosa aspect by the lights and shadows of gas.

There are three modes of obtaining communication: by the ground surface, by the tunnel below the suface, and by an artificial surface above the ground. The tunnel is the most costly, the level inconvenient and the least adapted for passengers. Projected tunnel lines are estimated to cost 130,000*l.* per mile, through London; to form double lines on the street surface would not cost more than 3000*l.* to 4000*l.* Then, again, there is the question of traction. If horses be used, they will have no advantage over the street surfaces, and there will be the mephitic air to contend with. If the locomotive be used, there is the steam and sulphurous vapour to get rid of. If the atmospheric system of traction be adopted it involves considerable cost and difficulty, and especially in forming junctions. On any kind of plan yet proposed, and even if the original principle were adopted of making the vehicles fit the tubes or tunnels,

so as to propel by their whole surface, that also involves mechanical difficulties, and valve doors at junctions like a system of coal-pits. If rope traction be adopted, there are the difficulties already experienced of breakages and accidents, and the intolerable noise of the sheeves for the ropes to run on, bad enough in the open air, but unbearable in a cavernous depth. The best apparent mode of solving the difficulty —regarding the tunnel as a passenger line— is by some kind of accumulative power-engine, as the forces of springs coiled by engine power or by compressed air. But on any plan the annoyance to short passengers would be considerable, descending some thirty feet into a vault to be carried a short distance, and then ascending again to the level. Still, there are three millions of inhabitants in London, and there may be sufficient amongst them possessing "strange tastes," to assist the revenue of the realm of alternate gloom and gas, and odours not redolent of roses.*

* The above was written some time back, while the Metropolitan line was in embryo. The writer will be glad to find that the resources of art have furnished a solution to all his objections, when the line shall be opened.

This underground railway presents some peculiar features. It was remarkable at the outset for passing through the legislature without opposition. Few cared about it, and fewer understood

The Greenwich, Blackwall, and other lines, are raised above the surface of the ground, on brick arches. The chief apparent reason why this should have been done, was to permit transit below them. To carry a railway line requires very heavy brickwork, but to carry light vehicles and foot-passengers, a comparatively light structure might be used.

Supposing it were in contemplation to lay out a new street in a new town, or in the suburbs of an old town, the true plan would be to consider the under surface as entirely belonging to sewers and drains, and quite unfitted for either dwellings or stores. The ground-floors should serve for the purpose of stores, and the street surface should be ap-

it. Making holes and passages of greater or less size under town levels has been always a profitable operation, on account of its unpleasantness, which kept competition away, and left it to a select few, who appreciated the aphorism that it gave a result of "clean money." In the making of the Metropolitan line the marvellous resources of English skill and energy in dealing with matter have been put to the test. Contrivances without end to meet new circumstances have been resorted to, and the papers and drawings would furnish a railway library. Nationally speaking, the gain in experience would be worth the outlay, even though, like the Thames Tunnel, it failed to be a path for passengers. The streets will be largely freed from goods obstruction in passing the river from north to south, and though we may doubt whether it will any way affect omnibus traffic, it is probable that the central communication between the metropolitan lines north and south of the Thames will be a great gain.

plied wholly to the purposes of railways. Above these, at a given height, should be the real street for the shops and dwellings, removed one story from the earth's surface, and thus there would be an easy means of getting rid of rain and mud. In fact mud would not exist, because there would be no materials for mud-making above, either by horse-carriages or by foot-passengers, and the transit on the rails below would prevent the disintegration of the roadway. The ancient city of Chester had the shops and dwellings raised above the roadway, for the sake of security against sudden violence from stranger visitors, believers in Merlin; and if the inhabitants of our streets could be persuaded to move their shops to the first-floor, a much pleasanter promenade would be provided for their customers, and an atmosphere much more conducive to health. Clearer, brighter and more elegant shops, would thus be provided, and the street would be really duplicated, for there would be no difficulty in arranging such terraced streets for the transit of light carriages as well as foot-passengers.

It is possible that in some circumstances such a system might be applied to our existing streets. Even now people enlarge their

shops into the first and second floors, and the saving of destruction to valuable property by the absence of dust and mud, is a very important consideration at the year's end. Some of our physicians have calculated the waste of life by the inhaling of granitic and other dust, and every arrangement tending to get rid of dust and smoke, and mischievous moisture, is an approximation to making the town as healthy as the country.

The attempts that have been made to lay down rails on common roads have not been judicious. To place a mass of timber underground as a foundation, liable to rot and difficult to get at to repair, is a mistake, and a still greater mistake is, to make too light a rail. Moreover, the edges of the rails must in all cases be guarded by paving, in order to prevent grooves being cut in the softer material in which they are bedded.

There is another difficulty; such rails must belong to the public and not to monopolists. The object professedly aimed at, to keep the monopoly of the edge-rail, while proffering to give the advantage of the tram to the public, is a transparent pretext. To use the tram it would be necessary to alter, at a great expense, the width of the wheels of some thirty varying classes of vehicles, and if they were altered the

monopoly of a flange to the wheel would be worth nothing, for the vehicles on a well-arranged tram would run quite as lightly as those on the edge-rail, unless the flange-wheels were greatly enlarged and of better construction.

The problem must some day be solved, and it will probably be, not by giving up the proprietorship of the streets to private companies, as in New York, but by the street-owners amending the structure of their surfaces and foundations.

The necessity for this is every day on the increase, for the time must come when the low, swampy and unwholesome ground will cease to be occupied as dwellings, and be restored to its natural use as garden-grounds. Even gravelly Camberwell is less wholesome than clayey Islington, and the latter is resorted to in some seasons, by the inhabitants of the former, for change of air, just as Brighton subserves general London. Had the "man-minded offspring" of the Eighth Harry ever rowed down in her barge through such a Thames as the present, and beheld such purlieus as are now found round Deptford and the "Seven Islands," and elsewhere, and the blighted blossoms of the remnants of the rich fruit orchards, she would have called around

her Burleigh and Bacon and their fellows, and bidden them take order that no more dwellings should be made in such localities, as contrary to the health of her lieges, and not adapted to the growth of full and developed manhood. Could these grounds have been reserved for vegetation, population must necessarily have gone to the hills, and the results upon this heart of our nation called London, would have been marvellous. The want of facile transit caused people to congregate in unwholesome contiguity, and the existence of facile transit will remedy the evil.

Too long have great cities been the haunts of vice, of luxurious sense and squalid poverty —too long the abodes of perennial disease. From the aggregation of men in cities civilisation has arisen, but still an imperfect civilisation. In the pursuit of wealth, health has been neglected, the cultivation of the poor has been forgotten, and the perception of this is now making way. We have palaces, but we have also hovels. Having hovels, as a consequence we have the diseases of hovels—humanity stunted of its full growth in body and mind. This is not a necessity, but a result of wilfulness and neglect.

Fairer site for city never existed, than this of our London. Margins of hills and rising

grounds, with a magnificent river rolling through them. Middlesex on one side, Surrey on the other; and around the river bottom belts of meadow land, and sites of once gardens, and orchards, and pastures, as the fragmentary remnants still show, but now desecrated with thousands of unwholesome dwellings, where water rises within a foot of the surface. The true sites of southern London are the rising slopes of the Surrey hills, and no city could well be imagined more beautiful than a north and south London, with the clear bright river, and orchards, gardens, and meadows between, nourished by the organic detritus that now pollutes the stream. The time will come, when the denizens of London shall fitly govern themselves—that owners of land will not be permitted to "do as they will with their own," by erecting inefficient buildings on unwholesome soil, to produce a deterioration of humanity; and when we better understand the possibilities of transit, and all people shall understand the conditions of health, the unwholesome dwellings on the low grounds will be abandoned for better erections on the higher sites. The thoughts of the philosopher will become the text-books of the Legislature, prescriptions will exist conformable to reason, and

the standard of humanity being prohibited from sinking below the conditions of climate and soil, with all the aids of art to boot, we may hope to raise up a race of men with unmistakable attributes, God's images upon earth, of whom it shall be said as they pass, "There goes a Londoner;" as of old the Greeks said, "There goes a Spartan or an Athenian"—a race of men upon whose type others shall mould themselves. To be a citizen of London then, when London ceases to be hedged in by a narrow ancient boundary, will be a prouder boast than that of ancient Rome. It is our national boast that the sun never sets within our boundaries, and beholds no slave therein. It shall be our boast also that within our boundary there exists no dwelling in which the highest and richest might not exist in comfort, and no human being, who could degrade the proudest dwelling by his presence therein. It is the boast of England that she has quelled all human foes by the valour of her sons. Let it be her boast also that she has chased disease and premature death beyond her boundaries, and that the standard of human life has grown to its highest pitch; that while the lower animals are improved, it has been sought also to show what humanity may become in its

highest phase; that those privileged to be born and bred in England can preserve and transmit health of body and mind of a more vigorous kind—a health more full of life, and that it is not the country races alone, but indigenous Londoners also, who can make permanent the race, said at present not to extend beyond three generations.

Narrow streets, ignorant dealing with detritus, insufficient light, dirty dwellings, smoky atmosphere, impure pools, and stimulants to quicken jaded life, are all artificial causes of disease, and all within the scope of human remedy. Naturally, supposing the marshes removed from the boundaries of London, there is no healthier climate existing, and London may become in time one long city, covering the rising grounds on either side the Thames valley from Richmond to the sea, with the low ground for its gardens and meadows.

Not in our time! No, perhaps not, but at least we may sow the seeds in our time, and our born children may reap some of the fruit; and, after all, our enjoyment may be as great, though of a different kind. The magnitude of a great exploit has a chivalrous beauty of aspect in it which the achievement does not always excel. The thought of heroism gives

also heroic pleasure, and we in London stand on a magnificent vantage-ground to contemplate the "to come." All nations, as well as our own provinces, are our tributaries. They toil and spin, and grow corn and rear beasts, and catch game, and the spoils of art, and nature, and industry come to London. Food and clothing are provided for us in return for the use of our capital and our brains. Let us use these brains fairly, understanding that there are uses for our brains and for our wealth far higher than mere luxury and ostentation, and we shall at no distant period reform all that is faulty in clothing, food, fuel, and shelter. Within the reach of art are many things desirable, easy to be procured, but not yet accomplished. The heart leaps at the known possibilities embodied in these matters.

Food, clothing, fuel, shelter, warmth, light, exercise, pure air, material beauty of form and colour, avoidance of mere drudgery, and a wholesome amount of leisure and recreation—give us these, and the artificial will grow out of the natural in books, painting, sculpture, architecture, gardening, and all the sciences and elegancies of life. As yet we possess these things as samples only for the masses to look up to, in the possession of the few. Palaces have we for the few—for the wealthy—but for

the many we simply mock them by a glimpse of a palace of crystal to gaze on, but not to inhabit. Yet if we went rightly about it we might cover acres of land with better shelter than the Crystal Palace and at small cost, with gardens for the multitude, where they might learn gentleness and elegance, away from the loathsome dens to which rough weather now condemns them. We cannot gather grapes from thorns nor figs from thistles, and if we condemn men to abodes fit only for vermin we must expect that they will be imbued with the attributes of vermin, and be governed by the "law of prey."

Recognising an iron or steel surface, whether of rail or tram, to be better than any other known material for wheels to run on, it is still certain that rails will not enable persons or goods to be delivered direct to every house. For this purpose roads must be formed with untrammelled surfaces, whether iron or other. With heavy loads such as coals or machinery, when running in a straight line, it is true that we may yoke on any number of horses with more or less advantage, but in turning corners, only one or two horses are available It is, therefore, desirable, to be able to concentrate great power in a small space, not merely to turn corners, but to economise space in straight lines.

So far as we know, only steam can do this, and, consequently, many minds are at work striving to accomplish it, under heavy discouragement from the absolute power given to the Secretary of State in the metropolitan districts. But steam requires a very heavy machine, and under a heavy machine a rough and uneven road, apt to sink, requires a very broad bearing surface to the wheels. For this reason, in Boydel's plans broad shoes are made to fall in succession under the wheels, and under them a soft road is actually better than a hard one. Steam at a slow pace is thus made to traverse a ploughed field as well as an elephant can, and move over apparently impracticable obstacles. Other road locomotives require to have very broad wheels, and all kinds of surfaces are resorted to on the wheels to obtain adhesion, one great difficulty hitherto prevailing.

The power in these road locomotives is obtained with small cylinders by operating through toothed wheels and pinions, just as heavy weights are moved by a slow-moving train of wheels to a crane; but this power does not prevent the wheels from slipping on the road. To ensure adhesion, the Bray system is, by means of eccentrics to protrude in succession a series of teeth through the centre of

the wheel tires, forming a cog in the road, but tending to damage the road unless on paving, and then subject to the difficulty of occasionally pressing so hard with the whole weight of the machine as to damage the connexion.

Examining the question carefully, the writer arrives at the conclusion that all moving machines to be effective must possess qualities similar to those of the animal structures to which they are analogous. An animal has a framework of bones, connected by joints through the medium of cartilage and muscle. Destroy the cartilage and muscle, which are a series of natural springs, the animal power of locomotion disappears, as in a horse long used on hard stones, when the muscles and tendons of his feet fail, and he begins to stumble. The veterinary surgeon then applies hot wires to his legs, and practically re-hardens and tempers his springs.

What legs and feet are to animals, wheels are, or rather should be, to locomotive machines. The animal foot, with its free joints and muscular springs, adapts itself to uneven ground, fitting equally over the whole surface of the foot, and securing adhesion without slipping, if soft-footed. If a hoofed animal, the adhesion is less perfect, but the hollow surface

capable of altering its level partly compensates; and in addition to the tendon springs in the feet, the whole frame is elastic by reason of the muscles.

If we examine a locomotive machine, and especially one of those used for steam traction on ordinary roads, we find it altogether devoid of what should represent muscle—springs. There is a great weight on the axles, and the friction thereon is greatly increased by the absence of springs. The geared wheels and pinions strike with their teeth a succession of blows and recoils. The wheels are rigid circles, of great breadth to prevent them sinking into the ground, which on uneven surfaces bear unequally and on small points, upon which they slip while crushing the road.

If the tires of the wheels be made of flexible elastic steel, supported also by flexible springs, so that they will adapt themselves to uneven surfaces, taking any required angle and slightly flattening, the tendency to slip will disappear, the road will be saved as well as the machine, the wheels and machine may be lessened in weight without reducing the power, but only rendering it more available, and a speed of six to eight or ten miles per hour may be attained when desirable. The economy will not be so great as with a thoroughly elastic machine used

on rails, but in this mode practical machines may be attained applicable to street and road use. They may be made, if required, as elegant as any other vehicle, but to make them complete, they must be made smokeless and noiseless, when they will cease to be objects of dislike to the leisure public. After all, the Secretary of State's edict is, perhaps, a useful kind of hint on slovenliness, and will prove a good stimulus to progress.

There is a fallacy prevalent as to road locomotives that may also be exploded—the fallacy that inferior workmanship may suffice on roads, compared with what is required on rails—the contrary being the fact. On the rail the engine is a simple locomotive; on the road it is a complex locomotive. When completed with all the essential principles recognised, it will be capable of drawing properly constructed trains on roads, with the disadvantages and advantages of being steered by the driver, and it will become also a common machine for moving and hoisting heavy weights in workshops and warehouses, movable power being substituted for stationary power.

CHAPTER XI.

THE WORKING MEN OF RAILWAYS.

PERMANENT WAGES ESSENTIAL TO IMPROVEMENT—ASSOCIATION FOR EXPENDITURE—DEFINITION OF "CLASS" AS COMPARED WITH "CASTE"—MEN NOT BORN EQUAL IN A WORLDLY SENSE—WISDOM AND KNOWLEDGE—ARTISTS AND LABOURERS—ARTISANS—FIRST, SECOND, AND THIRD CLASS ON RAILWAYS—ANALYSIS—MONEY VALUE—POWER—HAND-WORKERS AND HEAD-WORKERS—COMPETITION OF CLASSES—POSSIBLE MOTIVES—INDIVIDUALS RECIPROCALLY BETTER THAN EACH OTHER—MEN MISFITTED TO THEIR OCCUPATION—WASTE THEREBY—POPULARITY—INTELLECT AND GENEROSITY ESSENTIAL TO HIGH PROGRESS—RAILWAY MOUNTAINS REMOVED BY FAITH—CLASS ANTAGONISM—SOURCES OF ATTRACTION—WHAT IS POVERTY—VARIOUS KINDS OF POVERTY—INSUFFICIENCY OF COMFORTS—LABOUR NOT DEGRADING—WHY UNPLEASING—UNCLEAN CLOTHING NOT NECESSARY—GRACE IN CLOTHING, AND DURABILITY—FOOD OF WORKING PEOPLE—INTELLECTUAL CULTIVATION—CONVERSATION—MORAL QUALITIES—GENTLEMEN AND GENTS—WHAT IS A GENTLEMAN—WOMEN—HOW TO EXTINGUISH POVERTY—ECONOMY OF DOMESTIC LABOUR—EDUCATION OF CHILDREN AND ADULTS.

A CONSIDERABLE number of persons amongst the leisure classes of England are now earnestly at work trying how best to alleviate the evils

that flesh is heir to amongst the poorer classes. We have ragged-schools, and shoe-black brigades, and street-crossing sweepers in uniform, but it appears that most of them labour under the difficulty of expending the earnings of labour in modes very far from economical as compared with the processes by which material wealth is produced. The writer is not finding fault with the earnest exertions of philanthropists, but it may, nevertheless, be useful to enter upon the analyses of the causes that tend to keep class apart from class more than Christianity warrants, and which impediments Lord Shaftesbury and others have striven to remove. To try the experiment fairly, a class of persons should be taken, in the receipt of good and certain wages, and in whose locality existing appliances may be turned to account with a very trifling cost.

It will be well first to state the physical and mental differences that keep classes apart, and the possible processes by which the difficulties might be removed, in the hope that some of our railway directors may take the initiative in setting the example of further progress in civilisation. The writer is far from being a believer in socialism, so called, but he does believe in association for expenditure as well as

in association for production; aiming, in truth, only at carrying still farther forward the associated processes that give water to great cities without a labour-entailing well to every house—that give gas in a similar mode, and that have, to a very limited extent as yet, facilitated our travelling operations. The writer does not believe in any system of paying the idle at the same rate as the industrious, or the unskilled as highly as the skilled, but he does believe that such an amount of economy may be induced, as will place all in a far greater condition of comfort and progress than they have ever experienced before. This thing accomplished, and a pattern set, there will be no difficulty in imitating it in other localities, and we may gradually remove from us the imputation and reproach, that while England is the wealthiest nation of the earth, and the abode of the greatest luxury, it is also the abode of great misery among the working classes. And if it cannot be demonstrated that a better system is impracticable, or that it involves too great cost, it will be a duty to try it, amongst the great body of railway shareholders. There must be a strong desire that those who serve them should be well cared for, as an advantage to their own property to keep the best

men about them. A cotton-mill or an iron-mill would be less fitted for the experiment, as the workmen as well as their wages are more fluctuating. On a railway the workmen are an army, a regiment, a fixed body in constant work; in a manufactory they are uncertain.

The word *class*, in its commonest meaning, has reference to the various ranks of which society is composed. It is analogous to the word *caste*, as applied to Eastern India, the difference being that in India caste is, or was, hereditary in all ranks, and people are for ever confined, they and their descendants, to the class or caste in which they happen to be born. Thus, if a man be born of a brickmaker class, he must continue to make bricks only, even though his natural faculties be those of a philosopher or law-giver. This one fact in the history of India is sufficient to account for its continuing under its native princes an abode of slaves and tyrants, producing only hereditary articles of consumption and commerce, and making no progress in civilisation or power till the advent of conquerors amongst the natives—English, French, Dutch, Portuguese, and others—composed of classes, but recognising the right of every individual amongst them possessed of the requisite facul-

ties to rise to the highest ranks from the lowest, stopping short only—and that not always—at royalty.

In the British Empire, a man born in the labouring class may rise to be a foreman, a master, a manufacturer, a merchant, a landlord, a duke, if he possess at his birth the requisite faculties, and by circumstances or industry acquire the necessary cultivation of those faculties together with wealth.

We have heard much talk of the doctrine of equality—that all men are born equal, and that women are the equals of men. In the Christian sense this is true; all are equals before the Creator, men and women, whites, olives, reds, and blacks. But in the practical worldly sense none are equal. They are born each with distinctive faculties—peculiar aptitudes; from their birth some are born with high mental faculties; they possess acuteness to perceive and to acquire knowledge, and wisdom to apply it. The meaning of the word wisdom, being dominion over knowledge, does not alter the fact that many persons may possess considerable knowledge without the judgment or wisdom to apply it. And so also a man may possess considerable wisdom without great knowledge, for want of the circum-

stances to acquire it. He may be confined all his life to a solitary neighbourhood, and deprived of the means of learning.

Other men are born with combinations of physical and mental faculties; not poets in the highest sense, but men possessing imagination and artistic skill—architects, engineers, musicians, painters, sculptors, authors, actors, dancers, and so on. Others, again, are born with inventive faculties and manual skill and dexterity in the arts of construction. Others with only manual skill, as artisans exercising no imagination. Others are mere labourers, exercising only bodily force; others are mere waiters on machines, requiring little bodily force and little skill beyond knack.

As a general rule, men are valued according to the rarity of their faculties, combined with the extent in which those faculties are in demand, and make themselves obvious by their power of obtaining and also of accumulating money. The practical English nature first digested this fact into a simple formula upon railways—first, second, third, and fourth classes. They are simply money classes, measured off by their several capacities for payment.

The poet, the wise man, the philosopher,

are unquestionably the highest classes in the great scheme of creation, but yet they are to be found riding third and fourth class unless living on hereditary wealth. Generally they are not appreciated by the many—the masses—and it is the masses who make individuals wealthy by wide-spread small contributions. It was said of old, "Wisdom crieth out in the streets, and no man regardeth her."

In the first class ride the men of hereditary wealth and the men of large business brains, who organise the disposal of thousands and millions of money. In the second class ride the men of smaller business brains, who organise the disposal of thousands and hundreds, and also the men of large brains, with their capital not yet risen to the level of their faculties. In the third and fourth classes ride working men, who form the staple of the community.

Practically, the business brain is the highest class in the money-making sense. It is the business brain which is the great distributor of the community, the go-between of the producer and the consumer; and when was it ever known that the distributor did not serve himself first and best? Proverbially, cooks lick their fingers. Nor must we grumble or

repine at this dispensation. The business brain is the organiser, the preserver of order. The business brain makes bread dearer when corn is scarce, and thus makes the short supply hold out by short allowances. The business brain produces profit and accumulates productions. Sometimes the business brain, with more knowledge than wisdom, makes blunders by misfitting supply to demand, but, upon the whole, in this our England the balance is marvellously well kept up.

But though first class as regards money apportionments, the business brain is probably far from first class as regards happiness. It possesses power, appointments, direction, but it has much anxiety, some softening of the brain, some lunacy, and, moreover, a discount on the threescore and ten years allotted to general humanity.

At the root of money the secret motive is power—with merely vain people, the ostentation or semblance of power. This beggarly ostentation is the great vice of the age, leading to the commission of crime. Ostentation "thinks scorn" to go in working garments, in the pursuit of honest industry. Where laziness makes one thief, ostentation makes fifty. Sadleir, Paul, Robson, Redpath, and a host of

others, simply wanted to *seem*, they did not want to *be*; their *morale* was on a level with that of the commonest servant-maid ruined by a love of dress, or the valet borrowing his master's clothes, and we know not how many men are in the same condition, eating out their miserable souls in anxiety, for the sake of deceiving Mrs. Grundy into a belief in their importance. They wear fine clothes and keep horses and carriages, and worse things, and gamble and buy pictures, and patronise bastard art, and wear a hypocritically devout aspect, to come at last to the felon's garb and the hulks, like civilised savages as they are, foregoing, like natural savages, all future good for the sake of a transient gratification in living a mountebank life.

Political economists divide the industrious classes into hand-workers and head-workers. The popular idea makes a very empirical division—those who work in their ordinary clothing, as clerks, foremen, masters, &c., and those who require a peculiar garb to work in. Many head-workers are very hard hand-workers also, and the sedentary life is very far from play.

The working classes proper—*i.e.* the mechanics, artisans, and labourers—have an ad-

vantage over the trading classes, whether mere buyers and sellers, or the manufacturers who buy, make, and sell. The working classes have less actual temptation to the utterance of falsehood. From time immemorial the buyer has offered less than he means to give, the seller has asked more than he means to take; the operation is a fencing with wits in which the keenest gains. In ancient days profits were made with the longest and keenest sword; in modern times it is the glibest tongue that comes off victorious in competition. Profit was originally the cost of making, it is now the payment for superintending the making and distribution; the workman competes, and suffers many evils thereby, but his wages do not fluctuate uncertainly from day to day and week to week, like prices current. He *may* maintain a conscience, with a less loss of morality.

Amongst the various classes of society there is a constant struggle. Every class is striving to keep down the class below it and climb into the class above it. This struggle is not peculiar to the lowest, but pervades all alike. "Come along, Jem," says the coalheaver to his mate, "we cannot sit talking here to such a low fellow as a dustman." "I wonder at the

assurance of those Joneses in speaking to us," says the aristocratic Mrs. Peter Fitz-Flunkey, while she is striving hard to curtsey to a baronet's wife, who again is dying for a notice from the countess, who is anxious to be on a footing with the duchess-in-waiting at the Court. And so also a faded reputation, which is denounced in *poor* mediocrity, will be soldered up by wealth, or by intellectual eminence or power. But the Fitz-Flunkeys are no match for the vigorous intellects that claim as their birthright the choice of doing wrong at their own will. The Wild Boar of Ardennes winked at the theft of the plundered plate, by the strong and fearless robber who had hewn down foes in battle, but mercilessly hung up the mere thief who stole, without sharing in the fight.

It may be that the strife of the inferior classes to raise their position arises from a desire to avoid unrefined society, and exchange it for that which is more refined. It may be a man's reverence for that which is better than himself—disgust at inferiority. But it may also arise from ostentation; and it is very certain that many waste their means in striving to keep up an appearance equal to that of their superiors in wealth.

Still there are larger numbers with instinctive perceptions of that which is good and pleasant in things and companions. They would fain associate with those whom they esteem as their betters; they have a positive reverence for that to which they are denied access.

The term "betters" does not give a clear meaning. A better position by means of money is not a ground for reverence. "Better" in other respects is merely relative. Every man and woman is better than some other man or woman in some particular. A man may be a better poet, and worse ploughman; a wiser man, and worse workman; a more earnest philosopher, and a worse engine-driver; an excellent engine-fitter, and a very bad stoker; a capital joiner, and an execrable smith; a first-rate painter, and a very bad joiner; an unimpeachable duke, and a very bad turner; a very useless king, and a good locksmith, like the poor French king at the Revolution.

But a man may also be a very bad workman at everything, and yet an honest, moral man; and if so, deserving of respect for fulfilling his duties in the sphere he occupies, to the best of his ability.

A man gets his money on the large scale by

the exercise of his intellect—on a small scale by the exercise of tasks not requiring a large intellect—or by manual dexterity or skill. But there are also some varieties of manual skill into which intellect largely enters, as with great painters and great musicians.

One of the most difficult cases is that of men misfitted to their occupations. A man is born with some particular aptitude or fitness for some particular class of work—joining, engineering, chemistry, or others. In early youth he may have no opportunity of seeing or knowing the thing he likes, and so is put to something he does not like—probably the profession or trade of his father, or one of his relatives. He gets into employment or business, which he does badly, though to the best of his ability, and he is forced into the unnatural position of opposing all those better fitted for his work, under the fear that his means of earning his bread may be taken from him. Thus the necessity of providing for himself and family makes even a wrong in his estimation the semblance of a right. Thus a very large proportion of the actual work of the world is done by persons misfitted to it, and a large proportion of their time, and of the time of men who are fitted for it, is wasted in

strife, engendering evil passions. This is the true meaning of the cry that has spontaneously arisen of late, "The right man in the right place." There was once a man who inherited the trade of a watchmaker from his father, and after making bad watches till sixty years of age—pestering all his friends to martyr themselves on bad watches for his sake—then at sixty discovered that he had a positive genius for modelling human heads and faces. Had this poor man obtained the run of a modeller's shop in his boyhood—how much more profitably—with what an avoidance of waste would his life have passed.

Conscious dislike of their occupations leads people to disown them as much as possible, and to try to appear something else; and it also leads to what are called "hobbies," pursuing that which is useless, for the sake of some mental gratification.

Intellect is the great element leading to wealth and power, and amongst certain classes intellect without morality, representing vulgar power or cunning, is the object of worship. Hence comes the phrase when a man has accumulated money, "He has done the trick." One fine summer's morning the writer found his path impeded at Hyde Park Corner by a

crowd of peculiar people, whose faces and garb betrayed intimacy with horses and betting, and those pursuits by which money is got without work—sometimes. At last a shout arose, "Here he comes!" And certainly no "conquering hero" could have excited more enthusiasm. Apsley House contained no such hero in the perception of that mob. The writer's curiosity was excited, and he ventured to inquire, "Who's coming?" Very contemptuous was the reply of the respondent, eyeing the writer all over with a look which seemed to say he pitied his ignorance, "Vy! don't you see? It's Crocky!" There was a mingled affection and reverence in the tone of his voice as he named the highest type of his class, one who, beginning the world in the ranks as a fishmonger's boy, had by the acuteness of his intellect, and without any exertion of what his admirers considered grovelling work, won and appropriated to himself on the windy side ot the law, a large amount of wealth out of the pockets of the governing classes. "He had done the trick!" But it was a very low species of triumph.

Most men like to be popular. Proud men like a select popularity—a popularity amongst critical minds. Vain men are quite satisfied

to be popular with the crowd. Fools, especially wealthy or titled fools, if in abundance, are much more acceptable to vain men than first-class philosophers, who are in very small number. Wise men and good men, who are of wholesome natures, also like to be popular, to exercise influence, but they covet not the popularity which attaches itself to low or mean passions. The popularity they seek, is not an adulatory admiration, but a sympathy, a friendship, a recognition of the truth and beauty of their own nature in respondent feelings; they care not for classes, for mere rank or mere wealth; they care only for personal worth, qualities, and accomplishments. If such men exist amongst the wealthy, they seek out the kindred spirits who may chance to be amongst the poorer. If they be amongst the poor, those very qualities tend to make them shrink from contact with the wealthy who are not worthy, or the wealthy who do not seek them. They are not of the tuft-hunter, not of the snob class; they look through the clothing of humanity, good or bad, and detect the essential qualities of the human being beneath it; they are not amongst the men seeking to put down the lowly, while clinging to the skirts of those above them. Conscious of what they are, they seek not to seem what they are not;

they are genial by nature, instinctively great, and cling to all that is lovable in humanity.

Intellect is much, but it is not all. It is the growth of the brain, but not of the heart, and the strong heart, coupled with a moderate intellect, is ever more widely popular than the highest intellect that can exist without a generous nature; the very highest cannot exist at all without generosity. It is the union of the highest intellects with, and quickened by, the generous emotions, that constitutes the kings and leaders of humanity—of genial humanity; for, base as may be the aspect which individual humanity sometimes assumes, the axiom is still a true one, that the voice of the people is the voice of God; the spontaneous utterance that ever wells up unprompted in recognition of great deeds, of high and noble virtue, the instinctive spirit of Christianity that glows in men's hearts, and was ready to believe before it was preached to them; the spirit that prompts to national virtue, and builds up a true nation always ready to help onward progress, to cry out against cruelty, and to cheer on all other nations striving for the right of individual growth, with true heroic souls.

Human happiness exists in human sympathies. It is human sympathy with excel-

lence that in the aggregate prompts classes to seek admission into classes higher and more excellent than themselves, according to their perceptions. It is human sympathy, and not what is called snobbishness, that leads hard-handed workmen to join grip with heroes and great men. It was human sympathy, and not mere vulgar patriotism, that welcomed home the Crimean heroes. It was human sympathy that freed the slaves in our West Indian colonies, and proclaimed that the sun which never sets in our Empire, should never thenceforward shine on a slave within its boundaries. It is human sympathy growing with the growth of intellect that will never cease from the work it has commenced till the phase of human ignorance be passed, and the impediments that keep man apart from man shall be removed:

> "Till man wi' man the warld o'er,
> Shall brithers be and a' that."

The tendency to union amongst men and classes is ever on the increase. The spiritual axiom, "By faith ye shall remove mountains," has frequently found a material application. It is faith of another, though still imperfect kind, in one another, which, by the aid of joint-stock companies, has removed so many mountains of earth on our railways. It is this faith

which has created regiments and armies of peaceful workers—disciplined and obedient as armies of soldiers or navies of seamen, yet only volunteers by the day or week, on our railways, with small governments, and generals, colonels, captains, and subalterns, who are obeyed with rare instances of mutiny.

Still class repels class, though there is much affinity with individuals. Let us examine into the causes.

Aggregates of individuals unite themselves together from interest or from liking. Thus we have a college or collection of surgeons, of physicians; a company of apothecaries; City companies, or guilds of many various trades; societies—geographical, geological, zoological, entomological, botanical, archæological, architectural; British painters—water-colour and others; institutes of law; inns of court; institutions of engineers; army and navy and united services, and many other clubs; and we have mechanics' institutes and literary institutes, and benefit clubs, and fire and life and annuity insurance companies, saying nothing of railway, mining, canal, and others.

In clubs formed for association, members are elected by ballot, which gives the opportunity of excluding those who may be personally dis-

agreeable by habits, conduct, morals, eccentricity, or other circumstances. This is quite reasonable, because the pleasure of association must arise from certain similarities of perception and tastes, which attract and do not repel. In the self-same magnet we find that one end attracts and the other repels. In chemistry acids attract what are called alkalies, and lime is essential to attract substances from iron ore, and ensure the flow of the metal in the smelting-furnace.

Most men possess what the great German writer Goethe calls "elective affinities," and also repulsive antipathies. The affinities, produce affection and love. Antipathies, forced into contact, produce hatred, and in some cases murder, as painfully illustrated in Joanna Baillie's play of "De Montfort." There are natural repulsions which cannot be avoided; there are also sources of artificial repulsion which may be removed. A mathematician would have little attraction towards a hatter or a shoemaker, unless the shoemaker—no uncommon case—were a mathematician also. A landscape painter would have little sympathy with a maker of tallow-candles, in that capacity. A mere fine lady would not feel at home with a body of mere sempstresses, unless

perchance the sempstresses had great taste in apparel. A soldier would be in little sympathy with a Society of Friends. Only the universal poet, such as Shakspeare—or a high philosopher taking in every phase of humanity as of God's creation—could look on all, quarrel with none, and enjoy many, or all of them.

Circumstances—which still prevent all the members of a nation, who may be born with equal faculties, from equally cultivating those faculties—still keep men apart from men. Personal faculties, qualities, accomplishments, are the causes of attraction.

A well-formed face, large and capacious brain, susceptible nerves, well formed limbs, good stature, fine tone of voice, muscular strength, expressive eye, finely organised hand, are physical qualities in those who are naturally well born. The absence of some, or more, or any of these things, is a departure from the highest standard, and constitutes inequality of birth, or departure from the aristocratic standard of nature. It is, therefore, important to a man what father and mother he may happen to have, and whether there may be in them that mutual superiority in opposite qualities which induces physical perfection, or the nearest approach to it. Children

with this happy organisation may be born in the lower as well as the higher ranks of society, but there are contingencies in both. The poor may be surrounded with squalor and ugliness; the rich may be surrounded with too much luxury and concomitant vice. But, upon the whole, the chances are much in favour of the intelligent rich. So long as poverty shall exist, people will not be born equal, even though endowed by nature with equality of origin.

What is poverty? Not the mere absence of money, though the want of that involves the absence of most useful things. A man may possess money, and yet be devoid of knowledge—of accomplishments. Poverty is a question of possession or non-possession of many kinds. The absence of natural and artificial beauty to gaze on, is poverty. The absence of pure air, of warmth, of sufficient and wholesome food and drink, and the needful varieties of them, is poverty. The absence of clean and spacious lodging, of clean and graceful clothing, is poverty. The absence of pure and wholesome water, the absence of sufficient light, is poverty. The absence of books of knowledge, of the means of travelling, of instruction, is poverty. The absence of exercise,

of healthy amusement, of pleasant association, of affection, is poverty.

These various kinds of poverty are borne by many, and must continue to be borne, because the world has not yet arrived at a surplus of all the things essential to comfort, and the distributors, as is natural, will continue to help themselves first, and liberally, before they divide the remainder. But this condition is by no means a necessity, were the labour of the world all applied usefully and without waste. We are coming to that, but slowly; and in the mean time let us inquire what remedies may be applied to alleviate our present imperfect condition.

There is nothing materially degrading in labour. The ancient Scandinavians thought it quite reputable to forge their own weapons as well as to use them; and to sow and reap their own hay and corn crops, as well as to reap where they had not sown, both by sea and land. But though not naturally degrading, men in the southern states of America and elsewhere, contrive to make labour artificially degrading, by reducing black men who labour, to the condition of slaves. Intelligent manly labour pursued in the open air, or in healthy workshops, is a pleasant gym-

nastic. Gentlemen play at cricket and fives with great physical exertion; and in the company of working men, their gamekeepers, they work very hard at shooting, and also at joinery and ornamental turning work. The act of labour in itself clearly involves no humiliation. The being paid for it cannot make it disreputable, any more than the labour of the gentleman who goes out shooting with his gamekeeper, and sends the game to market.

But the act of labour, whether working in shops or in the fields, causes great perspiration, and dirties the clothing. By reason of his liberal purse the gentleman has spare suits, with servants to keep them clean and laundresses to wash his linen. The workman with small wages has but his working and his Sunday suits, and insufficient shirts and stockings. He wears his clothes after they are saturated with perspiration; his health suffers for it, and this is the first line of demarcation separating him from the "curled darlings of our nation," bathed and washed with perfumed soaps, and dispensing odours as they pass.

Let us rub off as we go! We are on a railway with all the means and appliances that have done so much to facilitate transit. Can they not, without cost to the company, be

made to facilitate clean clothing to those who are employed by the company?

Those who work are far from rational in their personal arrangements. In the army, soldiers are provided with what are called fatigue dresses for working in. It is quite clear that it is an unwholesome thing for a man to sit down in the evening in the clothes which he has saturated with his day's work. He should have a change of clothes and linen, and a thorough washing of his body so soon as his day's work is over, and this cleaning it would be advantageous to perform in the works, because his reading-room, his lecture-room, and other means of instruction are there, and it would save him loss of time in going home; and, moreover, it might be more cheaply done. His washing at home is dear and troublesome. With the abundant boilers at the works it should be a mere fraction of the present handicraft cost. The rationale of a workman's clothing should be thus: A man should have the best possible suit of clothes to work in—not necessarily the most costly—just as a sportsman has the best possible suit for his peculiar work, and the converse of an American workman, who generally has the very worst one—a suit as little as possible re-

—*i.e.* some man in position invents or adopts at his tailor's suggestion a peculiar form of garment adapted to his peculiar figure. There-upon the imitative classes follow his lead, with-out reflecting that the varieties in human form and complexion, need varieties in the form and colour of clothing to constitute grace. Short waists and long waists, and no waists at all, and clothing fitting like skins, as though people had been melted into it, and clothing without any fit at all, and broad-brimmed hats and narrow-brimmed hats, and bonnets like coal-scuttles, and others like scallop-shells pinned to the back of the head, and balloons for petticoats, filthily sweeping the streets, and Clarence boots, and Bluchers, and Hessians, and Wellingtons, and top-boots, and jack-boots, all come in as fashions without any reflection as to whether they are adapted to the requirements of utility, which should ever be the basis of grace. This kind of imitation is snobbishness—absense of originality. There are two classes of garments required—the suc-cinct or close garments for bodily labour, and the loose, easy-flowing garments for rest and leisure, not of gaudy finery as courting notice by display, but harmonising with the indi-vidual—the very opposite of those classes whom we see sometimes dressed in a pea-

green coat, a scarlet waistcoat, and yellow breeches, a bad likeness of a very ugly parrot.

Besides being more healthy, the graceful garments are really the most durable and economical. A Spanish cloak derived from the old Roman toga lasts a man a lifetime, and descends to his son as an heirloom. The South American poncho, formed of an oblong piece of cloth in one piece, with a slit in the centre to put the head through, resembles in graceful effect the Greek pallium. It is very durable, gives pleasant freedom to the body, and is convertible to the use of a blanket by night and very commonly a table-cover by day. And this simple robe is the every-day wear of large numbers of wild Indians, more rational than large classes of our civilised people.

When we consider that the human body varies its dimensions in hot weather and cold, and before dinner and after, there appears to be a great absurdity in a coat made to any exact girth. The rational plan would be to convert our frock-coat into the ancient tunic, or modern blouse, or waistless over-coat, or paletot, girding our loins with a girdle after the ancient utilitarian and not ungraceful fashion.

The practice of fitting coats and pantaloons, and shoes and boots like skins, gave rise to

the distinctions between "bespoke" and ready made. To wear bespoke garments was formerly the attribute of a gentleman. The workman, beyond the pale of fashion, was supposed to be clad in ready-made misfits, after the fashion of soldiers and sailors.

Hats were the first general break-down of the bespoke gentility, stockings followed, then shoes and boots, then trousers and waistcoats, and lastly coats and over-coats. Tailors had become men of many stitches. The stitching-machine is rapidly destroying that trade of cutting up webs and joining them together again; and even probably the tailor, eschewing the "bespoke," will betake himself to the mills where broadcloth is produced, will then resume his ancient artist name of *tailleur*—one having knowledge and skill in human form and proportions—and will then produce, instead of flat webs of cloth, completed and seamless garments in all gradations of size, just as shoes, stockings, and hats are now produced.

And thus the workmen will have attained cleanly, wholesome, and healthy bodies, gracefully garbed in broad or other cloth, and so far not distinguishable from the select or elect of the land. But our bodies need food, and according to the food we use, so will our per-

sonal appearance be influenced. Working will not make us unrefined, but certain classes of food will. Different constitutions require different kinds of food to digest and assimilate. We are accustomed to satirise foreigners as garlic-eaters, poisoning with their breath those who talk to them. But if we drink large quantities of beer, we shall distend our stomachs unnaturally, and mixing it with strong cheese, onions, tobacco, and other matters, we shall make up an odour very unpleasant to those who feed differently. We have an undoubted right to eat and drink those things if we like, and if we come honestly by them, but we cannot in fairness expect to associate with those who do not like the odour. So, if the working classes would establish a claim to mix with refined people, they must sacrifice their propensities to eat strong and indigestible food, and confine themselves to wholesome, even if coarse, food, which they can assimilate.

All this—cleanliness, decent clothing, unobjectionable food—is within the reach of men of economical habits, common sense, and moderate wages. The sources of physical repulsion between classes may be thus removed.

But more than physical conditions are required between man and man. There must be

positive attraction as well as negative repulsion. Companionship is made-up conversation, which needs knowledge, taste, and accomplishments. A man cannot talk incessantly in company, of the processes by which he earns his bread; he must therefore read books and join instructive classes in order to know and to understand, and the more books he knows and understands, the wider will be his sphere of conversation. It is not absolutely necessary, but it will be an advantage, to understand languages, and to have an acquaintance with the rudiments of the general sciences. It is well also to be able to sing and understand music, provided a man be not vain—endowed too largely with what phrenologists call love of approbation—for in such cases he will be led astray, waste his means, and fall into difficulties.

For there are moral qualities as well as physical and intellectual qualities. One of the first things a man should understand is, to possess self-control. He must live within his income and not get into debt. It is a trite saying, that if a man has twenty shillings per week, and lives on nineteen, he will live in comfort and may grow rich. If he has but twenty shillings and spends twenty-one, he will go to ruin. Plot he never so cunningly,

cheat he never so acutely, he will find that in the long run society will be too much for him, and he will sink under a heavy arrear of accumulated interest on the damage he has done. There are people who do accumulate by dishonesty short of legal crime, but they are very few, and though they make what the world calls a "success," they do it at the loss of all happiness. They lead a life of constant suspicion, like a spider in the centre of a web, distrusting all their agents. They live a lie themselves, and reap the reward of falsehood in being able to believe no one.

The working classes are accustomed to speak of each other individually as "gentlemen," shortened off by the Saxon economy which exhibits itself even in the use of words, to "gent." Satirical criticism has upon this basis given a new meaning to the word. A gent is one who, not being a gentleman, would ostensibly pass for one. The distinction is instinctively marked by acute people. The gents wear ostentatious clothing, ostentatious jewellery, and ostentatious gold watches and chains, are dogmatic, and use ostentatious language in society; yet even, as it is said, that hypocrisy is a tribute which vice pays to virtue, so the gent, in trying to pass mock externals for realities, pays a tribute to the

qualities supposed by him to constitute a gentleman, that mark which all people aim at, and which even a king must be, to be personally influential. What, then, is a gentleman?

One who does unto others as he would that others should do unto him. Gentle but not fearful. Of high courage, he scorns to lie, and is ready to take all consequences rather than debase himself by falsehood; one who never oppresses any one, and much less a poor or weak man, or is rude or unkind to a woman; one who never contracts debts he has no means of paying; one who is ready to help his neighbour, or the helpless, whenever he can, without destroying his own usefulness; one who is genial and generous of nature, not necessarily in the giving of money—for he may have no money to give—but in the giving of kindness. Men may give money because they have it in surplus, but a man who would freely give a fifty-pound note in charity might also refuse to rise from his sofa after dinner to save a neighbour from being killed. Such a man is not generous in the heroic sense, but only in the sense of a cab-driver who thinks that the test of a gentleman is to pay double fare. A gentleman is not rude or rough of speech or manner, but is gentle-voiced, arising from a

gentle nature; one who would not hurt from unkindness, but yet would be firm of purpose and not suffer himself to be imposed on by knaves or fools.

It seems clear, therefore, that every one, even with very moderate means or moderate understanding, may be a gentleman. But he must be just, or he cannot be generous. The man who robbed his employers largely, and gave away money freely, was not generous, but merely ostentatious—a gent and not a gentleman, and probably the severest punishment to such a man, sensitive only to appearances, would be to exhibit him daily in the most humiliating employments, in the presence of those he had been accustomed to deceive with false pretences.

What holds good of men, holds good of women also, in their sphere. A lady is the counterpart of a gentleman, not necessarily rich, not idle, or imagining that doing nothing, dressed in fine clothes, is the attribute of ladyhood. A woman with a family, who has to attend to the careful expenditure of weekly earnings to keep her family in a state of comfort, has practically more to do, more faculties to exercise, than the husband who earns the wages, directed by his employers. But a woman may be very poor, have her hands

very hard, and still be a lady in her heart and external manners. Blessed are the children born of such mothers; happy the men with such wives.

How to extinguish poverty, to insure a surplus for all the natural wants of humanity in food, clothing, lodging, warmth, so that all the higher faculties may have time to grow, and thus extinguish the great mass of crime arising rather from want than from vice, is the great problem to solve, in the struggle for human happiness. Fortunately, we are each day and each year approaching nearer to the solution. It is a cheering feature in the conduct of railways, to find a recognition of the advantages of instructing the working people, as well as housing them. Let us inquire how this may be more advantageously carried out, not to make the people into grown children, doing all things for them, but teaching or enabling them, to help themselves, so as to increase the available result of a given amount of wages.

In mills and manufactories worked by machinery profits are made by the adoption of labour-saving processes, without which the mills could not be worked at all. These or analogous processes are adopted in railway workshops, the neighbourhood of which, by

reason of the numerous workmen and their families, become small towns.

Many of the processes adopted to economise manufactures might equally well be adopted to economise domestic labour. Thus, by means of the engine and boiler and gas-works, hot and cold water, as well as gas, might be supplied to all the dwellings. Upon the same principle warmed air might be applied from a central warming apparatus, and of a pure kind, to all the dwellings, which would very conveniently and economically reduce the amount of open fires, diminishing labour, the effect of draught, and the chances of taking cold.

Hot and cold water being delivered at the top of the dwellings and running downwards by gravity into the drains would remove a large amount of drudgery from the women.

A cheap apparatus fitted for cooking by gas would remove another amount of drudgery.

An infant school would be another obvious advantage in leaving mothers free occasionally from the charge of their younger children—repairing their clothing and obtaining air and exercise.

A Kindergarten school, in which little children acquire the habit of cheerfulness, and

while learning to sing and dance, acquire also the perceptions of truth of form in modelling, and harmony of colour in weaving paper, and the facts of geometry without knowing it by name—in which they find out their natural aptitudes instinctively.

Schools* for boys and girls from eight to fourteen years of age would be the next necessity. Reading, writing, arithmetic, and drawing—the tools of knowledge—would, as a matter of course, be taught therein. But, in addition, there would be needed the practical tools of the useful arts. Gardens, and tools to work in them; both open-air workhouses and greenhouses; workshops with joiners', smiths', turners', fitters', shoemakers', and other tools, adapted in size to the boys. There would be natural gymnastics, alternating with book instruction as a pleasure, and the result would be, that at fourteen years of age the boys would be instructed workers instead of mere spoilers of material when draughted into the workshops. Their drawing and working would proceed hand-in-hand. They would for the

* The schoolrooms should all be ventilated by machine, trusting nothing to discretion; the influx of pure warm air and the efflux of breathed air should be constant, and in proportion to the number of persons.

most part be capable of all the repairs of the schools and dwellings before commencing the earning of wages. The voluntary labour would in many cases be more enthusiastic than the paid labour.

In the girls' schools, in addition to the reading, writing, arithmetic, drawing, repairing clothes, and so on, there should be taught cooking and all the domestic operations.

The reading-room of the adults should be well supplied with books quite of other kinds than those treating of their work, by which they earn their wages. Books of science and practical science there should be; but there should be books of amusement also. "All work and no play makes Jack a dull boy;" and it is but a small number of men who are of the studious and aspiring spirit which lifts them out of the ranks. Self-help does not always take the direction of the accumulation of money. Such men as rise, always contrive to get at the knowledge for which they have a peculiar aptitude, and it must be remembered that, talk as we will of teaching, all we can really do is, to place knowledge before those who have an aptitude to acquire it. If there be not a natural absorption, all our cramming will avail little. The leaders must ever be the

few, the led the many, till such time as men can go altogether without leading strings, by their own instincts acting upon the mass of accumulated knowledge. If boys can be brought up with abundance of different operations in view, there will be less chance of their mistaking their vocations in life, and the world will grow richer on accumulated material wealth.

In all really great nations the quality of reverence is of spontaneous growth, and pitches upon the natural chiefs and leaders with instinctive impulse. A nation that dwells only in fear of its masters or leaders, without reverence, is in a very hopeless condition. Reverence is another word for religion—a binding together—and an aggregated number of human beings can only be a nation by virtue of being bound together. Without reverence for chief or leader, without belief or faith in manhood, not to one man only, but to many men, a so-called nation is but a rope of sand. It were a pleasant thing to behold the proprietors and workers of a railway bound together for progress—a nation on a small scale, setting an example how to minimise human drudgery and maximise human happiness—how to give men's wives leisure to ob-

tain instruction in all those things that go to the making of a happy home, without which we cannot have contented men or hopeful children. Mothers more than fathers go to the creation of joyous boyhood and heroic manhood. Mothers only can be the moulders of those cultivated qualities in girls that make them fitting wives for worthy men.

It is a certain thing that a railway company setting this example would attract to them all the best men, and that good men would react upon themselves in the shape of a better dividend. In time it would be found advantageous with such servants to stimulate exertion by a corresponding advantage from the payment of improved dividends, as in a Boston or Nantucket whale-ship. If railways are to be managed for the benefit of shareholders, officials, and directors alike, to this conclusion they must come.

There is nothing new in the proposition. It is but the better development of principles as old as the everlasting hills, the principles being superadded to the present haphazard arrangements.

The plans proposed for keeping railway workmen in health are precisely adapted for the comfort of volunteer soldiers.

CHAPTER XII.

CONTRACTORS, NAVVIES, AND THEIR WORK.

TINCATCHASCAN LINE—EXCESS OF COST OVER ESTIMATES—SUCCESSFUL CONTRACTOR—CONTRACTING SHREWDNESS—CAREER—REVERSE OF FORTUNE—A FOREIGN CONTRACTOR—ANECDOTES—OUTWITTING A RIVAL CONTRACTOR—RUSKIN AND RAILWAYS—EMERSON—PINE TREE IN A FORMER ENGINEERING ASPECT—ACTS OF THE APOSTLES OF CIVILISATION ON RAILWAYS—SAXON APTITUDE—MISS BARRETT—POSSIBLE BEAUTY OF RAILWAYS—DEFECTIVE ARCHITECTURE — UTILITY OF SPECULATORS IN SHARES—ENGLISH RACE OF MEN—ORIGIN.

In a well-known region, called "Tincatchascan," a railway was once made in the early time, in which four times the original capital was absorbed. This first begat in directors of railways about to be made, a nervous fever of meeting shareholders with estimates exceeded, and so commenced the practices of what are called guaranteed estimates. Supply mostly follows on demand, so some very shrewd engineers in that happy land were accustomed to project railways with a contractor in their train, just as a general moves with

his commissariat. The engineer was ready with his estimate and the contractor with his tender, and so there was no fear of mistake, if due care were taken not to under-estimate, —a rare occurrence.

One railway of some scores of miles hung fire; the directors were congested with their fears of exceeding the estimates, and so a shrewd man of business, a contractor, *i.e.* a man with a mind contracted to profit and a keen eye to discern the paths of profit, called on them. This man had made his way upwards, and passing through the process of sub-contracting, had obtained a glimpse of the upper glories. And thus he relieved the directors from their difficulties, by proffering to make the railway complete in all its parts, buy the land at the commencement, and, if required, to engage the station-clerks at the conclusion, with all the staff complete, so that his patrons might have no trouble, but begin business off-hand. But the latter condition—the staff and clerks—being simply a matter of patronage, the directors kept that trouble on their own hands.

Our contractor loomed on the directors' minds as a guardian angel, a guarantee against responsibilities, backed by sufficient sureties,

so the matter was without delay handed over to him, and he knew what to do with it.

It is remarkable that in the early times of railways the greatest profits were made in inverse proportion to the skill required in the work. The dirt-digger came first, and the locomotive engine-maker came last. Our contractor resolved to do nothing himself; he simply divided his entire contract—obtained at his own price—into parts, and every separate part he made the subject of competition amongst subordinates. The result was that he made a clear profit of 40,000 dollars per mile, or a total of 2,000,000 dollars.

It may be asked why did not the directors dispense with the large contractor, and let the sub-contracts themselves. For a very simple reason; the experiment had been tried and had failed in a former case, because the directors had not understood the business. The great contractor was a veritable distributor, doing the work which the directors were supposed to do, and distributors rarely forget themselves. Shareholders might complain, but what then? Shareholders do not work, and if they expected that they were to receive ten per cent. for the use of their capital while other people did all the work, they simply de-

ceived themselves. The public funds produced five per cent., the railway, with little risk, produced seven per cent., and as the risk rose, or was supposed to rise, the profit, or apparent profit, increased. If shareholders can do their own work as well as the directors or distributors they employ, they may reap a larger profit. But they must learn a business, to do this.

Our skilful contractor gave "perfect satisfaction" to the directors; they complimented him highly, and sent for him again when a branch line was to be made. "But in justice to their shareholders," they said, "they must put him in competition." He "had not the slightest objection; he was quite aware," he said, "that no one could work so cheaply as he could, and—who did they think of putting him in competition with?"

"Why, really, they had not decided; who did he think an eligible person?" "Oh, of course the directors would only think of reputable persons; he could have no possible objection to Mr. ——." So it was agreed that Mr. —— should be "written to."

Away went our contractor to Mr. —— beforehand, to explain that he did not mean to be interfered with in his own connexion,

and that if Mr. —— would send in his tender at a certain price he would receive a cheque for 10,000 dollars when our contractor, by a lower tender, had obtained the contract.

The appointed day came, and our contractor appeared before the board. The president again complimented him, but was sorry to say that he could not obtain the contract, for Mr. —— was below him in his tender. "Sold!" he mentally exclaimed, but plucking up heart of grace, he boldly proclaimed that there must be some mistake, and asked to be permitted to examine his own tender again.

While affecting to examine the tender he had time for thought. In a bland tone he asked, "What, gentlemen, may be the difference in amount?"

"A few thousand dollars!"

"Oh, I see it all. The line is single, with land and embankment for a double line. Does Mr. —— include works?"

"No."

"That is it, gentlemen. I include works in my tender, which makes my tender considerably lower than that of Mr. ——."

So our contractor walked out of the board-room with his contract confirmed. His partner, a nervous man with little business faculty, was waiting for him.

"I have the contract safe, but was obliged to throw in double works at a venture to cut out ——."

"You are very rash; you may ruin us some day by these rash proceedings."

This was a very mortifying remark to hear, from one who had so largely benefited by his shrewdness in the original contract, and was now largely benefiting a second time. But he contented himself by replying,

"My dear fellow, all the 'works' on the line are only two wooden bridges, and they together cannot come to 3000 dollars, so we make a profit of 7000 dollars extra by —— selling us."

He did not long remain in that partnership, but found another partner better suited to him. But had he been a wise man he would have retired with his gains. What he had done was not a process to be continued. The reason is obvious. All new things place one, or a few people, in a position of superior knowledge, which gives them a monopoly. If the new thing be an article in great demand, the accumulation of fortunes is the result. But knowledge spreads, and competition begins and increases, and that which began as a process of fortune-making becomes a process of fortune-losing. But the con-

tracting mind is rarely philosophic, and the impelling motive is the accumulation of a fortune, and then a greater and greater fortune, like the mére gambler in coin. The contractor in this case was a vain man, loving notoriety, with a strong desire to become a millionnaire and Member of Congress, and so on. Not being a man of high purpose, but only of high ostentation—the essential of Thackeray's snob—he went on and on to accumulate more money, but with each contract growing less profitable by the increasing competition, instituted by the foremen and sub-contractors, who had been the tools he worked with, and who understood the business of contracting as well as himself. To stem this opposition his active brain devised a new method. He entered into a league offensive and defensive with some other great contractors, to keep out all small ones by going in for lower prices and ruining them. In the process he found that he had ruined himself. Large estates and fine houses went as they had come, the accumulated five millions of dollars disappeared, and the contractor sunk again into the nothing from which he had sprung, or worse than nothing, a mere implement in the game of "beggar my neighbour," without a dollar to call his own beyond

the day's expenditure, part of a machine kept going because too many were interested to permit of its tumbling to pieces, and so damaging the general speculation of Tincatchascan.

Once, in a foreign land, a native contractor heard of the advent of a number of competitors overflowing from the stocked market of England. He went to "take stock" of them—make an inspection of them—and on his return remarked, "What do they expect to get by low prices here? Do they owe money to any one in authority here, or have they any to give away? I owe a million amongst those who have the patronage, and they are not going to be such fools as to give away to strangers the chances by which I may pay them."

As competition grew stronger on "letting" days, many contrivances were resorted to to "dodge" directors. Contractors would sometimes rely on friends at the board, or amongst the advisers of the board, to obtain a paying price, on the ground of their reputation. But even the reputable people grew too numerous. That which could be reduced definitely to form and quantity, left no scope except in quality, and that depended upon the skill and industry

of the inspector to pass or not to pass; and it was a serious risk to construct things of high amounts in value, with any uncertainty of their being accepted. But even respectability was frequently put aside for the sake of low price.

On one occasion a number of contractors of good repute, strong in the belief that the rolling stock of a new line would only be given to trustworthy builders, determined to obtain fair prices, or what they called fair prices, so they agreed to divide the different parts amongst themselves, each one putting a high price on what he was not to have, and a moderate price on what he was to have. For once they were satisfied that justice would be done, but on letting day a stranger went in for the whole at 20 per cent. lower prices, and swept off the whole, the directors being competent arithmeticians in ascertaining the difference in cost but not in value.

Time passed, the opening day came, and part of the stock was delivered. It was anything but what it should have been—inferior in labour and material; but the line was to be opened, and so the vehicles were received. The contractor lost 15 per cent. by the transaction, and the company were harassed with stock requiring incessant repairs.

In rails the same system has prevailed. Ironmasters have been pitted against each other, as to which should produce an apparent rail at the lowest price. At the outset of railways the rails were made of iron. Competition gradually produced rails in which a core, of what is technically called "cinder," is covered up with a skin of iron; and the cleverest foreman for an ironmaster was the man who could make rails with the maximum of cinder and the minimum of iron. In more than one instance has it been known that in relaying an old line the worn-out rails have been sold at a higher price per ton than the new ones were bought for; yet this would hardly open the eyes of the buyers.

The contrivances which are resorted to to get hold of one another's prices beforehand, by competing contractors, are manifold; and when they attend in person, they commonly put off the filling up of their tender till the last moment. Once a shrewd contractor found himself at the same inn with a rival who always trod close on his heels. He was followed about and cross-questioned incessantly, and gave vague answers. Within half an hour of the last moment he went into the coffee-room and sat himself down in a corner where his rival

could not overlook him. There and then he filled up his tender, and as he rose from the table left behind him the paper on which he had blotted it. As he left the room his rival caught up the blotting paper, and, with the exulting glee of a consciously successful rival, read off the amount backwards. "Done this time!" was his mental thought, as he filled up his own tender a dollar lower, and hastened to deposit it. To his utter surprise the next day he found that he had lost the contract, and complainingly asked his rival how it was, for he had "tendered below him." "How did you know you were below me?" "Because I found your blotting paper!" "I thought so. I left it on purpose for you, and wrote another tender in my bedroom. You had better make your own calculations next time."

But these things are not peculiar to railways, they simply belong to competitive humanity, and this competition is a valuable quality in the construction of railways; albeit, Mr. Ruskin can write in this fashion:

"And although I believe we have salt enough of ardent and holy mind amongst us to keep us in some measure from moral decay, yet the signs of it must be watched with anxiety in all matters, however trivial; in all directions, however distant. And at this time, when the iron roads are tearing up the surface of Europe as grapeshot do the sea; when their great *sagène* is draw-

ing and twitching the ancient strength of England together, restricting all its various life—its rocky arms and rural heart—into a narrow finite metropolis of manufactures. . . . There is need, bitter need, to bring back, if we may, into men's minds that to live is nothing, unless to live be to know Him by whom we live, and that He is not to be known by marring His fair works and blotting out the influences upon His creatures; not amidst the hurry of crowds and the crash of innovators, but in solitary places, and out of the gleaming intelligences which He gave to men of old. He did not teach them how to build for glory and for beauty, He did not give them the fearless, faithful, inherited energies that worked on, and drove from death to death, generation after generation, that we, foul and perverted as we are, might give the carved work of their proud art-spirit to the axe and the hammer; He has not cloven the earth with rivers that their white wild waves might turn wheels and push paddles, nor burned it up as it were with fire, that it might heat wells and cure diseases."

It is not so, John Ruskin! The workers of this world—of this our English world—are not mere hewers of wood and drawers of water. The contracted utilitarian abuse of doctrine that followed on the announcement of the philosopher passed away after a lapse of time, and was no more. It is the instinct of God that prompts the modern worker in his course, as widely as it prompts the preacher. The brave and heroic worker, faithful to his appointed task, even he whom men call "Navvy," the stern old Saxon, or Dansker, or Scandinavian stock, who, like his ancestry of the race of the Vikings, works out the mystic way of Providence, that the bread of physical life

may be placed in the mouths of himself and his brethren. He perchance knows not, or heeds not, the command that "man shall not live by bread alone"—suffice it for him, that man cannot live without bread.

"Parson!" cried out a rich farmer to a man of God in black garments, "why don't'ee put souls into the congregation?"—the labouring peasantry.

"Souls!" replied the preacher, turning an eye of indignation on the hard man, "souls without bodies! Provide you the bodies with fitting wages, and I will undertake to raise the souls. I cannot create souls in starving bodies."

No! no! not yet in our day must the reproach be raised that we work too much; while yet whole families are houseless and short of food; while men ask for bread and get stones to break in answer; while France, and Germany, and Italy make revolutions, incited, to a great extent, by scarcity of food; while black men are held in slavery that white men may have cotton to work on, and earn wages wherewith to feed themselves and wives and families; while wives and families work also; let us not be accused of working too hard at those processes which go to the diminution of drudgery; while far and near barbarism still

obtains, and men are as the "beasts that perish," let us not be turned aside from the work that is to work out their civilisation. "Pine forests" are doubtless better in their growth than as mere "wood to burn," yet that too is a part appointed to them. Well singeth Emerson of the pine-tree, and thus makes it talk, as does Tennyson by the oak:

"The wild-eyed boy who in the wood
Chants his hymn to hill and flood;
Whom the city's poisoning spleen
Makes not pale, or fat, or lean;
Whom the rain and the wind purgeth,
Whom the dawn and daystar urgeth,
In whose cheeks the rose-leaf blusheth,
In whose feet the lion rusheth:
Iron arms and iron mould,
That know not fear, fatigue, or cold;
I give my rafters to his boat,
My billets to his boiler's throat;
And I will swim the ancient sea,
To float my child to victory,
And grant to dwellers with the pine
Dominion o'er the palm and vine;
Westward I ope the forest gates,
The train along the railway skates,
It leaves the land behind like ages past,
The foreland flows to it in rivers fast,
Missouri I have made a mart,
I touch Iowa Saxon art."

All these uses the pine serves while man is in his infancy. When he shall grow up into full and ripened manhood, with the progress

of art, the pine may remain in its native forests unharmed, "to cover the mountains like the shadows of God," and also to catch the clouds and cover the land with healthy brooks and streams.

Years ago a party of engineers were walking through the grounds of Woburn Abbey, under the escort of John Farey. All were suddenly struck with the magnificent aspect of a large pine-tree, and stood still, saying nothing, lost in admiration of its beauty. One of their number at length, strong in his art, or mill-wright nature, burst forth into speech: "What a splendid water-wheel shaft that tree would make!" Years have rolled away, and water-wheel shafts are all made of iron. The pine-tree may grow and flourish for ever undisturbed by the engineer or shipwright. Nature has taught them the uses of inorganic matter.

Not even from the lips of Ruskin can we patiently listen to the vituperation of railways—the modern *Acts of the Apostles of Civilisation.* "Tearing up the surface of Europe as grape-shot does the sea!" Is this all that can be said of them, all that Ruskin can see with his artistic vision in

"The iron bands, the iron bands,
The proxies of men's clasping hands,
That bind together distant lands;"

that make the rough places smooth, and bring the ends of the earth together? Does he, in truth, prefer to see the grape-shot ploughing up, not the sea, but Europe? No, no! let but enough shot or iron be rolled into rails, and there shall be an end of war, Secession notwithstanding. Yet this he deems no desirable conclusion. He fears that we shall be plunged into inglorious sloth, that the builder up of towns, the civil engineer, will be more mischievous than the thrower down thereof, the military engineer. No, no! John Ruskin. We have seen shots fired in anger, and men slain thereby, and we have seen the peaceful engineering of these latter days, and out of our very hearts can we pronounce that the latter is the most exciting, the most satisfying. "Our rest" shall not become "the rest of stones," "grass" shall not "cover us" yet awhile, nor "lichens feed on us," nor shall we be "ploughed down into dust." No, no! we will harness our fire-steeds, and saddle and bridle them, and ride over the whole world's surface on the mission of "Peace upon earth, and good will towards men." Our work shall be incessant while there is a foe to struggle against, an ignorance to root out, or waverer to convince.

Why should the artist look down with con-

tempt on his working brother, that brother without whose help he had never become an artist. "We," say the Saxon workers, "have cut through the forest and let in sunlight upon you that you may paint your pictures with light and shadow; we built your houses to shelter your artist work from the weather; we built the ships that bear ye to and from distant lands; we maintain rule and order, and provide the means whereby ye build and endow churches; we have at times pulled down and destroyed churches in religious zeal, but we have also maintained peace and preserved other churches. We work for Catholic, and Protestant, and Puseyite, and Dissenter, and while we uphold the remnants of the mediæval time, we call on you to remember that such things are but histories, and that progress is forwards, not backwards. The past is less than the present, the future greater. Into that future—blinded it may be with the blaze—struggling forwards, dazzled and darkened by turns, but still struggling forwards—into that future, and through it, we plunge and rush, to win for humanity a fresh resting-place for centuries yet to come.

It requires a strong moral sense to look at the new things acting before us, surrounded

as they are by iniquities, and yet to discuss clearly the good that is in them. We see Hudsons, Capel Courts, and Stock Exchanges, with all manner of unclean things floating on the surface of railways, and we forget the good that lies under, that Providence is working out its purposes by the agency of unclean things. Miss Barrett once asked, with a scoff, anent our "resonant steam-eagles,"

> "If we work our souls as nobly as our iron?"

It is not difficult in answer to show that "the great *sagène* of the iron roads is drawing the ancient power and strength of England together, its moving life, its rocky arms, and rural heart," for no "narrow finite calculating metropolis of manufactures," but for the higher work of the civilisation of universal man; for his rescue from the thraldom of misery, and poverty, and ignorance, that man, universal man, may become the lord of all the earth, and not a miserable, quarrelsome assemblage of clans worrying each other's possessions like ferocious beasts. Wordsworth and others have vituperated railways, as destroying the sanctity of beautiful places. What do these charges amount to, if, indeed upon examination any distinct charges appear?

But it is asserted that railways are ugly. It may be admitted, while they are new. But so are all new constructions. New buildings of brick and stone are garish and ugly, so are new earthen roads, till nature or art has clothed them in green; new sandstone cuttings, new chalk cuttings are ugly. But this is only till they are overgrown with trees, and plants, and lichens, and herbage, and evergreens; the railway ravine, with its sweeping curve, is as beautiful as a natural ravine. The South-Western Railway, in some portions, is especially beautiful:

> "The heath, the heath, the upland heath,
> With the pine-ridge on the height,
> And all below the purple wreath,
> Gleaming in rich sunlight;
> And the sweeping curve of the glancing rail
> In the line of the dell below,
> Where the land-ships all, without oar or sail,
> Move onward in goodly row.
>
> . . . .
>
> O'er the gladdened earth's surface are whirled,
> By the iron steeds stride in the forest so wide,
> From the wilderness winning a world."

Turf the railway embankments and plant the cuttings, and nature will soon make them beautiful enough. The road-bridges above them may always be rendered sightly objects, if not in construction, by planting them

out and covering them with ivy and other climbers. The stations should not imitate Greek architecture. In great towns they should simply be business-like, in short, plain buildings, emblematic of speed and movement. The other stations should be rural, and the station-keepers should be encouraged to plant them with roses and honeysuckles, and every variety of plant that helps to make English cottages beautiful. In large stations in towns of great traffic, the objects required are space and air, with great spans and as few columns as possible. For these purposes metallic structure is desirable; metal made chemically durable, but not necessarily made to imitate stone architecture, nor the strange mixture of Gothic and Saracenic, and that Indian tattooing which we occasionally see.

These things are not progress, but obstacles to progress—waste of the means which should help on progress. But railway erections might be the means, as, indeed, they are, of conveying much silent instruction to the general community. Thoroughly to appreciate a wide field of utility herein—of true utility—it should be remembered what railways have done in clearing out haunts of squalor in towns, and exposing to view human wretched-

ness in Irish bogs, and dissipating miasma in marshes. Contrivers are still at work how to get the best results of transit, and it is for future times to convert mechanical structures and contrivances into pleasure-giving beauty. Happy the railway proprietors whose arrangements in building have been of the most temporary kind.

Thirty years back it used to cost more money to transfer a load of goods from the backbone of England to any seaport, than from that seaport to India. And all the transport both of goods and passengers was performed by horses, with an amount of cruelty few people are now aware of, and with an incessant nuisance of dust and mud alternating. This work, and an infinitely increased amount, is now performed by steam at an infinite reduction of cost—actual cost—not mere reduction to passengers, but practical daily cost, saying nothing of wasted invested capital. The mud and dust are not yet abolished, though they might be, but the enormous cruelty to animals has been abolished, while the speed has been doubled and quadrupled. The goods and passengers carried, mean—increased civilisation to the world. The cruelty abolished, means the refinement of the

English and other nations, a result that no Christian can contemplate without satisfaction: Were there no other results, these alone should close the lips of those who vituperate railways.

But the objectors will reply: "Think of the iniquities and immoralities which they have caused!"

Well, and what then? There were Law's Mississippi schemes, and hundreds of other schemes, long before the advent of railways. God has made nothing in vain, and even iniquities and unwise laws have a part to play in creation. Hudsons have their utility as well as the co-directors and co-shareholders, whose cupidity was the true origin of his doings. If a railway be required, it is quite clear that it must take some time to make—say three or four years—and during that time the money laid out can yield no interest. When done, if it pays more than an average rate of profit, it cannot last, because competitors will be at work, anxious to get a share of the surplus profit. If honest men propose to make a railway, to go without interest while making, and to obtain a moderate interest when made, without the power of selling shares and realising their capital mean-

while, the public will have nothing to say to it. But let the projector propose an impracticable ten per cent, or more, the shares are rapidly taken up, and the railway is commenced. The Hudson tribes are such juggling projectors, and pay themselves for their trouble—leaving their gulls to suffer—when they can. Shares and money change hands in a gambling process, where every one expects to get profit without work done, and the public gets the railway. It is sought to exact high prices to pay for the interest upon wasted capital, but this is not practicable. The shares fall to the value which represents the real and not the wasted capital, and they pay an average interest upon the former only. This only is the witchcraft which the Hudson tribe use, taking care to buy their shares very cheap, or to get them for nothing, and to sell them at an increased price.

The power of locomotion is a necessity to man. In many cases it happens that a man is born in a climate uncongenial to him. If he stays in it, he dies, or suffers incessant illness that makes him a pain to himself and others. He therefore requires the facility of getting away to a congenial climate, and of occasionally returning to his friends. As interchange increases between

nations, more of this will exist; for human affections are not to be checked by peculiarities of race, and thus probably was it designed by nature from the beginning. With limited means of transit, therefore, much misery must ensue. With cheap transit this misery will cease. Many a Spaniard and Italian in natural qualities is born in England and Germany; many a German and Englishman in Spain and Italy. Misfitted to their climates, they are useless to themselves and the world; fitted to their climates, they become producers after their several fashions. All such interchanges tend to draw close the bonds between nations, and ultimately to merge them into a cosmopolitan world wherein war shall cease. Wars between nations are a result of their not knowing each other, or, at least, of not knowing each other intimately enough. At present, the uses of railways are but partially developed. England, by virtue of its huge water-roads over the ocean, has become civilised faster than other nations. Men of all European nations have visited the "workshop of the world," where their ancestors came for war and peace purposes, and left their race behind them to mingle with the natives of the soil. And the English race—essen-

tially a mixed race—wherein the blood of Celts, Phœnicians, Picts, Scots, Romans, Danes, Saxons, Normans, and Dutchmen—and probably the best of each, was united to produce the universal man. They went forth into all lands—to America, to India, to Africa—leaving permanent colonies in all where the climate was favourable, and constantly renewing colonists where the climate was unfavourable. This mingling of races was the result of the ocean-road and shipping, combined with the plentiful blood of the fair-haired ocean-rovers so largely infused in the race. Ireland lacked this blood, and her population has remained stationary. France the same. The Celts are not an ocean-roving people. The Gallic cock is an emblem of Gallic inefficiency on the wide waters of ocean. This grand evil—the want of constant friendly intercourse between the nations of the earth, has kept up wars—sometimes by contrivance of the rulers, sometimes by mutual antipathies. This great evil will be utterly removed and rooted out by railways. There was a time when every English shire and county had terms of vituperation to bestow on its neighbours; when Scotland, Ireland, and Wales were at war with England,

till conquered. It was making roads through the Highlands that rooted out rebellion:

> "Had you seen but this road
> Before it was made,
> You'd lift up your hands
> And bless General Wade."

What England was, Europe still is. There were roads, but only for the wealthy few—till the advent of some few railways. But the wealthy few do not destroy national antipathies. It is the travelling of the many that must accomplish such a result. By the advent and extension of railways, the whole of Europe, the whole of the world, will assimilate to the condition of England, with the variation of climate. Little have they yet done, for they are but in their infancy. They have been sought for by individuals as a money-getting speculation, not by communities as civilisers. When they shall really be developed, it will be within the reach of the poorest of mankind to travel, and look on other lands.

Little do artists dream of the high purposes to be wrought out by the agency of railways, unless, indeed, they dream that high art and nature's bounties and wonders should be reserved only for the few, while the many toil to give them leisure. Would ye build

temples, oh ye men of art! temples to God? Would ye build these temples only for the rich? No; the true artist builds for mankind. Where, then, would ye place your temples? In the squalid haunts where men congregate, in the cities that have grown up in the days of barbarism? No, no; the high places of the land, the wild heaths and pine groves made by God, ere man was—where the lark sings, and not the dens where the mouse cheeps and the rat burrows—are the true sites for your temples, where the hand of the spoiler shall not come to build them round with dens of iniquity. And how shall the people go to worship at God's altars thus placed in the pure and holy air, how—but by the railways ye run down and scorn? Again, artists, would ye build temples to the drama, to the muses—where would ye place them save on the railway line? The day has gone by when it was a need for men to build close cities; and the time is coming when, as of old, the tree will again shadow the dwelling. Time and space have been vanquished, and the residences of regenerate man have yet to be constructed. Turn whither we will, do what we will in art, artistry, mechanism, agriculture, exercise, health, knowledge, or, if it

must be, war—in all things henceforth the iron way is the way of our worldly salvation, of our mental progress, of our soul's rescue from degradation. Look on us, ye men of high aspirations, as your veritable brethren, —we, the hewers of wood and the drawers of water; the mountain-borers, the valley-fillers, the hill-upheavers; the modern centaurs; begetters of the fire-steeds of the land and the coursers of the ocean; holding the physical world in our hands at the command of God, who has bidden us to make the rough places smooth that his people may dwell together in unity. Work ye, then, at your godlike art; let the temple rise, the sculpture grow, the picture start into life; let the poet sing and the sage speak, the prophet inspire men with his own spirit; but with all that, forget not that it was the hard hands of your despised brethren, the physical workers, with sweating brows and burning hearts, that first won for ye this world from the wilderness, and gave the vantage ground to stand on. Rough nurses have we been to nourish the germ of baby art; but lo! it lives, moves, and has being. We reverence ye for your beauty. Scorn ye not our strength that has shielded that beauty from harm.

"Look into the future, far as human eye can see,
See the vision of the world, and all the wonder that will be."

"Out of the strong comes forth sweetness. out of the eater comes forth meat." The English race is self-developing, like other organised creations or germs, just as certain plants thrive in certain latitudes and elevations, and others do not; and as plants removed by man to congenial regions, thrive, while others die, as the hot-house plant of one country becomes the open air plant of another; and, thus, do what we will, the race of Englishmen will remain Englishmen, unless transported to other circumstances, which will not permit the peculiarly English qualities to develop themselves. They are "racy of the soil." And were the whole race swept away to-morrow, and this island of long memories peopled with weaklings, not long would it so remain. The best blood of the North would again descend, as in the olden time—"the children of the pine"—and the world's battle would begin anew. Backward would roll the Celt, onward would press the Norseman; sharp keels would cut and cover the northern seas; and in a few hundred years, again would England be peopled by Englishmen—"racy of the soil," rough and rude; with "blood fetched from

fathers of war-proof;" with "horse to ride and weapon to wear;" but the coal still to dig and the iron to smelt; and the long course of interrupted industry to work into order and method. The hard large hand would grow to its fitting work, and the artist's fingers would pine; the Celt would be a savage and the Saxon a boor. "Whom God hath joined together let no man put asunder;" and the wars ended, Celt and Saxon intermixed, and substantial dwellings erected to make an artificial climate, English refinement becomes possible. Who shall now tell us of what blood were Shakspeare, and Bacon, and Milton—not what names their fathers and mothers were known by, but whence and how came that rare combination of brains and nerves, strong hearts and intellectual heads, that made them the world's wonder? Was it the red-haired Dane, of the large features and ogre mouth,

"That toss'd the sprawling infant on his spear;"

or the fierce Celt, who made human sacrifices in his Druid temple; or the swart Phœnician, bastard brother to the money-loving Jew; or the blue-eyed Saxon or Norwegian, loving the ale-cup; or the hard crafty Norman baron, with the church on his lips and sensual lusts in his

heart; or was it the Dutchman of the "purest Norse blood," too thick to run through his veins till urged by alcohol? Was it not rather, that out of the mingling of the highest qualities of all these, purged from their defects, those great spirits arose? We hold to this belief.

Throughout all nature, animate and inanimate, we seem to recognise two great principles—elasticity and gravity; and without their mutual action and reaction the world could scarcely exist. In man, the principle of elasticity is represented by the Celt, whose elastic energy all boils off in vapour, till controlled by the Saxon gravity, or moral force, which holds it down like the weighted valve of a steam-engine—if too tightly, producing dangerous explosions; if too loosely, producing no result; but at the right degree of pressure, giving world-wide advantage.

CHAPTER XIII.

FOREIGN RAILWAYS.

ENGLISH CONTRACTOR—JUDGE OF FOREIGN WORKMEN—WORK RESULT OF FOOD—SPAIN AND HER RAILWAYS—DON JOSE SALAMANCA: CAREER—SPAIN AND HER RETARDATION CAUSED BY WANT OF ROADS—CAPACITY OF SPANIARDS—CIRCUS—SPANISH ENGINEERS—SPANISH NAVVIES—ALLIANCE OF SPAIN AND ENGLAND—ENGLISH CAPITAL IN FOREIGN LINES—COLONIES—RAILWAY ROUTES TO INDIA—EUPHRATES LINE—LIGHT RAILWAYS.

THE English railway makers, like the freemasons of the olden time, when work grew scarce at home, migrated to foreign lands. Railway contracting is a trade that will not stop. In its process there is ever accumulating men and horses, and the materials called "plant"—barrows, ballast-engines, rails, sleepers, engines, and other things—not forgetting bonds and debentures. In some cases the making of a railway lowers the profit margin on these things, and either at high or low price a new contract must be obtained to turn them to account. And so our English

navvies go abroad to teach other nations their craft, so far as they are capable of learning it.

A contractor—one of our highest—one with manhood as well as railcraft, went to a foreign land, carrying with him some few leading men, and intending to employ natives, and proclaiming that all who could do as much and as good work as English "navvies" should be paid at the same rate, being nearly double the native wages.

Large numbers came to be hired, and they were ranged in rows. The contractor passed up and down the line to choose. He could not speak the "foreign lingo," but he could read in nature's book: so he chose his men. "You *bon*, you stay here—you *no bon*, you go away!" judging of their faculties by their faces and bodies. All jealousy of the foreigners was thus avoided. But another thing was soon discovered. The amount of physical work which could be got out of a man in the digging process depended upon the amount of strong food he was able to digest and assimilate, precisely as engine-power depends on the amount of fuel the engine is capable of burning, and supplying to the water in the form of heat. The foreign stomachs could not do this, they could not

digest a daily ration of from three to four pounds of meat with adjuncts, as the English navvies could, and they fairly gave it up, resting contented with a lower rate of wages at work they were fitted for.

But wherever aptitude existed for making railways, neither English engineers nor contractors long retained their position. European countries grew in railway knowledge by example, the American Union almost by instinct, though Canada was a foreign contract ground.

There was one country of Europe where the early advent of railways was accomplished by native energy and native faculties—Spain—that much-vituperated land, which is but little understood.

A man of genius, a native of Malaga, Don Jose Salamanca, whose life has been a marvel great as any recorded in Gil Blas or Quevedo, merchant, student, editor, banker, courtier, prime-minister, financier, contractor, all in turn, resolved to make a railway—the first railway in Spain. Strange to say, he resolved to make it wholly inland, far away from his native Malaga and all other seaports. People mocked at this as mere ignorance. But Don Jose knew better: he knew all the extra cost

incurred by moving heavy weights from the sea-shore, two hundred and fifty miles inland from the Mediterranean up a table-land elevation of three thousand feet. And he knew that without court patronage, in Spain, he could not make a line at all, and so he set about the thirty miles of the Madrid and Aranjuez—the London and Windsor of Spain—and he employed a Spanish engineer, and afterwards an English, to make the line, bringing all his materials from England to Alicante. How rails and chairs, and fastenings and switches, and crossings and turntables, tanks and water-cranes, waggons, carriages, and locomotive engines were transported by bullock-power and long trains of mules along that track of no-roads, and through the narrow crooked streets of towns, where houses had to be purchased and pulled down to make way for them, is like reading one of the labours of Hercules. How Don Jose fell from his seat of power into debts and trouble, and how his railway was delayed, and his English plant was lying about from the sea-shore to the capital, and how he rose again and stood erect, and got his line finished and opened, and how the astute Madrileños, when they first saw the locomotive

run, insisted that the mules were inside,—all these are *Cosas de España*, things that only Spain could produce, with the conclusion that Don Jose Salamanca, again a millionnaire, lives in the palace he built, and after long trouble finished, — more than many a Spanish Infante can boast. But though his railway from Madrid to Aranjuez was the first commenced, it was nevertheless not the first opened, for the hard-headed Catalonians, with Joseph Locke and his navvies, stole a march upon him, and opened the Barcelona and Mataro—their Liverpool and Manchester cotton-line on a small scale—and commemorated the event on a brass-plate. And now we find this Spanish universalist, Don Jose, making more lines, and even going forth from Spain to Nova Scotia, on railway enterprise.

It is a common error to suppose that the normal condition of Spain is laziness. It is quite otherwise. The prospect of any work whereby money is to be made, beyond the commonest drudging labour, sets the country in a ferment from one end to the other. Strange as it may seem, Spain has never yet been a country in the national sense of the word. The French sarcasm, truly expressed till lately its condition: "Africa beyond the

Pyrenees." It is still the country of a sultan divided into pachalics, under the name of provinces, and governed by a grand vizier who may be changed from day to day. It is neither more nor less corrupt than Turkish administration in Asia, and the people enjoy and endure, social freedom and political tyranny, together. The divan, or capital, is an anomaly, a mere geographical centre, that adds a large per-centage to the expenses of government; a place where there is little or no material work to be done, and where pachas, in or out of place, hold the centre of a great spider's web, stronger than usual, to gather black mail from every nascent industry. Spain is not a nation, but a mere bundle of disunited provinces, each of which, save where assimilated by railways, is alien to the others as Portugal itself, the latter being a kind of Egypt that has thrown off the yoke of the Spanish sultan, and holds the sea-gates of Spain—the mouths of her large rivers that reach to the ocean. This condition of things would be marvellous, but for the almost entire absence of roads, *i. e.* roads by which transit and general traffic could be accomplished—marvellous, inasmuch as all the other conditions that constitute a great nation are to be

found. Materials, and the means of creating produce, are in abundance, and there is absolutely no country in the world possessing a people of higher intellectual acuteness or more patient industry, or, all things considered, a higher individual morality. Let England, Scotland, and Ireland be placed in the condition of Spain for twenty-five years —if that were possible—by a disputed succession, and the laws be made only by military despots, changing from month to month, we should then present a spectacle from which people would fly for refuge to Spain.

Sovereigns and ministers dwell in Madrid—not to rule, in the sense of making order straight, but simply to collect taxes, paying soldiers only for that purpose, the minister and his pretorians for the time being, laying hands on everything; less the pay of the troops and the dissipations of the sovereign. A factitious capital, with a factitious population, brutalised by their only pleasure—the circus—and scantily fed "panem et circenses," will cease to exist, from the moment that the shackles shall fall from Spanish industry. When some true sovereign shall dwell elsewhere, and carry away the Spanish boast—the picture gallery—Madrid will gradually become

as Palmyra, a heap of ruins, even to the magnificent royal palace, that no one will think worth repairing, and where no more sentinels will be frozen to death by "the wind that slays a man while it would not blow out a candle."

But where is the master mind that shall unshackle the energies of Spain? Where is the gripe that shall hold her provinces together till they be fused? Where the "sic volo sic jubeo" that shall never will or order aught but stern justice; that master power over the minds of all natural men—men who abound in Spain, though not in Madrid? Who singly shall grasp the army and rule it, and make it know him for its master, and with that army make all Spain obedient to just laws? No man not strong enough in material power can dwell in Madrid, and be believed in by the provinces as a political saviour. He must wield the outward symbol till he has pulled down Madrid and all its abominations, and built up a whole nation around it. The circus, the emblem of physical brutality, must be no more, no longer the representative of national habits, ere the great heart of the nation can arouse to its true life, so long bound up in feverish slumber. In the old time, in England, our land was shired,

sheared, shred into fragments, and sectioned into parts, and a Yorkshire or Lancashire man was in social feud with Middlesex men, while their very dialects were a signal for mutual vituperation, and we only left off our bull-baits when we improved our transit. So in Spain the mountain boundaries mark distinct habits and customs, and the only appliances that can break down the tribal feuds—roads—are utterly lacking, save for the privileged orders. Men, and still more so women, are born and die in their native parishes, and talk of Madrid as a marvel that they have been told of, even as in the days of Gil Blas.

There is no lack of engineering faculty in Spain. The lack has been of the honesty to employ it effectually. There is an abundance of rising young men, willing to work for very moderate remuneration. There is abundance of laborious industry, to which absence of work is a privation. Thirty miles from Madrid I once beheld some two thousand peasants bivouaced on the bare ground for many days, waiting for the novel work the railway engineer was preparing for them, and a speculative provision-dealer erected some long ranges of buildings—which he christened by a Greek name—as a lodging for them when

the current coins for their daily labour might be forthcoming. But their economy was more than a match for him. Their lodging was on the cold—or hot—ground, twopence-halfpenny per night cheaper than the would be "tommy-shop" of Old Castile. These people gathered the earth into baskets, and carried it on their heads, to make embankments, like Egyptians. Another generation will use the barrow and plank as deftly as a Lancashire-bred navvy.

It is not industry that is wanting, not capital that is wanting, not skill that is wanting, only law and order. In Spain they have now contractors, Credit Mobilier men, and others, taking concessions by ministerial favour, or ministerial bargain, at twenty reals, subletting at ten, and so on, till at last the actual "blue blood" of Castile—the swarthy Titan upheaver of the brown earth, the dust from out which grows wheat and grapes and figs and olives—is brought down to three reals, great part of which is made to accumulate in his kid skin bag, by an economy more than Irish. It is not industry or saving that is the want of Spain. There are travellers who in hot weather behold Spaniards listless, and therefore proclaim them lazy. But is not Saint Monday regularly kept by workmen in

England? Work for work, pay for pay, and guidance for guidance, a Castellano, a Biscayno, a Gallego, will do as much work as an Englishman, and with quite as much intelligence. But with sea-coast custom-houses, and inland custom-houses, and with government manufactories of tobacco, and with an eternal system of smuggling, and an indefinite power of taxing everything that may be profitable, it is not strange that the only intellectual industry which is pursued is that of obtaining monopolies of bribes. In the old time, Spain had America for her treasury, and the Casa del Oro—the Golden House—at Seville was not an empty name. That has gone by. The revenues from industry are improving, but the true mode of producing revenue would be to proclaim free trade, *i.e.* a moderate per-centage, *ad valorem* duty on every bulky article in a ship's manifest coming to a Spanish port, whether native or foreign. Her mines, her fruits, her corn, wine, and oil, would then be rapidly worked, and the process would be nearly self-acting. No legion of custom-house officers would then be wanting to assist in smuggling. A stringent law on false manifests, and well-paid collectors, would soon produce a very large revenue, and Bar-

celona would continue to supply her cotton-mills direct, with goods from England, as she now does, without the need of putting on the Spanish custom-house marks in Manchester.

So long as Spain is kept in a condition of Bœotian indolence, so long will inquietude prevail from unused faculties. To employ her latent energy she must be a commercial country; must buy and sell. To do this she must have railways to transport her produce, and bring her people in contact with each other, from the Bay of Biscay to Gibraltar and the Mediterranean. This done, Spain and England would become as colonies to each other, linked by the closest bonds of mutual advantages. And there does not appear any reason why the railways of Spain, *i. e.* the levels, embankments, viaducts, cuttings, and bridges, should not be laid out by the government engineers and executed by the soldiers, who must be maintained till peace and order shall become a normal condition of the country. Our own sappers and miners are a sample of what can be done with soldiers not wanted for fighting, and the Spanish intellect would make rapid progress. Soldiers do not dislike work, especially when extra pay is the result. On the contrary, mutiny amongst

privates and disorderly conduct amongst officers, are, together with diseases, a common result of idleness.

But a small fraction of the lines of railway needed in Spain are yet entered on, and these, largely by French speculators. Either the Government must make the lines themselves, or grant concessions to private companies. In the latter case an enormous premium must be given on account of the apparent risk involved by past repudiation. If the Spanish Government would solder the breach in its financial repute, the money needed therefore would be repaid very quickly in the obtaining loans at a lower rate of interest. If the Government makes the lines, as was sometimes done in France at the outset, and was done in Belgium, and if it does it by the employment of the soldiery, it would be a comparatively easy thing to procure rails and rolling-stock in exchange for produce. Spain might thus procure her railways with comparative ease, and with a contented soldiery earning good wages, and not liable to be made the tools of plotting generals.

The history of Spain is that of a brave people warring for centuries to throw off foreign dominators; winning province after

province, and erecting each into a limited monarchy under the successful leader for the time being; then the gradual aggregation of the monarchies without the aggregation of the peoples subject to them; then a tyranny, finally cemented by the judicial murder of the patriot Antonio Perez, under the walls of Saragoza, by the tyrant monarch, who thus sealed the destruction of political freedom, while leaving a considerable amount of social equality; and from that time to this Spaniards have bowed themselves quietly down before the name of king, whatever might be the worthlessness or viciousness of the individual wearing the crown.

But not, therefore, has the inherent genius or valour of the people disappeared. In front of the Palace of the Cortes stands the metal semblance of the great writer of Spain—the one-armed hero who fought in Lepanto's fight, to help Christendom against the then tyrant Moslem—poetry, honour, and valour combined. To this very day is the humour of Spanish men the keenest in the world; their language is poetry, and for their valour let Saragoza speak. Give them again a Pelayo and a Cid, and they would revive the deeds of old. They cannot do this under the dege-

nerate race of fribbles that now calls itself nobility. Living portraits of Quevedo, the satirist of bad kings, are to be met with at every street corner. Farce writers, prolific as Lope de Vega, as witty and as worthless, would start up like mushrooms were their pay as high, and the moral grandeur of Calderon would not appear to be all lost, and the Church would be purified from the abominations of those now calling themselves her servants. The paintings of Murillo and Velasquez show what Spanish art once was, and might be again, when the growing wealth of the general community shall be to artists what the national wealth and the wealth of the Church once was. It is a desirable thing for England that Spain should grow up to be a great nation. No southern people are so kindred to us in habits of thought and modes of action. In no foreign country are Spaniards so much at home as in England, and no people are more popular in Spain than are Englishmen. Spanish men and the old seafaring race of Portugal are our natural allies, and we ought to use our whole endeavours to make them one people, engaged in constant free trade with ourselves and all the world, exchanging food for the other necessaries of life. The

Spanish peninsula is our natural garden and hothouse, our outlying farm on the opposite shores of the bay whose name rings in our naval annals. The workshops of the peninsula will be cis-Biscayan for series of years to come.

It is sometimes asserted that English capital has been sunk and wasted in making railways in foreign countries. This may be the fact as regards English shareholders to some extent, but in regarding it as a help to commerce it may be doubted whether we have not materially benefited by the outlay. We certainly benefit by the Canadian outlay, and by Australian outlay, and so shall we do by the Cape and all other colonies, East and West Indies inclusive.

It is true that we have an easy and tolerably safe road to our colonies—the ocean—but to our East Indian colonies—*i.e.* to a large portion of the English empire, it is a great convenience to have a land road, also, as far as possible, to avoid the long distance round the Cape of Good Hope. For individuals, or small numbers, the passage across France to the Mediterranean by Marseilles, or through Austria to Trieste, is simple enough, but for the passage of troops we need our own road,

without asking permission, and that road must be through the Straits of Gibraltar. Our route hitherto has been through Egypt, but our neighbours are taking all possible pains to convert Egypt into an appanage of France, so that they may charge us a toll, or bar up our passage when it suits them, at their own pleasure, unless we do as we have done before, take it away from them again, and restore it to its right owners. Egypt may be regarded as a dependency of Turkey, subject to a tribute, but without the right to make any public roads except by permission of Turkey. Turkey might any day forbid our passage through Egypt if France could coerce her, but in such case we should probably take the matter into our own hands, as stopping our right, or at least our *custom*, of way.

But it is worth while to consider whether the pass through Egypt to the Red Sea is the best route we could take. The railway belongs to the Pacha, and he may charge what fares he like, and if he gets in debt to France, and mortgages the railway, the prices are not likely to be lowered. Let us therefore consider another route.

If we pass up the Straits of Gibraltar we arrive at Malta. If we go across France by

way of Marseilles we also arrive at Malta. If we go by way of Trieste we arrive, down the Adriatic, at Candia, where no doubt the Sultan would give us good coaling and other accommodation. From Marseilles to Candia is a distance of about 1300 miles, and from Marseilles to Alexandria is about 1600, while from Trieste to Candia the distance is only about 1000 miles, and from Gibraltar to Malta and Candia the distance is only about 1700 miles. The distance from Gibraltar to Alexandria is about 2000 miles. The whole distance from Gibraltar to Seleucia, a port in Arabia, is 2300 miles, and from Trieste to Seleucia it is only 1600 miles.

Arriving at Seleucia we are within 20 miles of Antioch, as the crow flies, 60 miles from Aleppo, and 100 miles from Jaber Castle, situated on the head-waters of the Euphrates, to which vessels as large as Thames barges can arrive in all seasons. To construct a railway the distance would increase to about 125 to 150 miles. It has been estimated that a railway can be made for about a million and a quarter, and the Sultan has given a grant to an English company of a concession for 99 years, with a guaranteed interest on the outlay of 6 per cent., taking the plant at a valuation, at the end of the time.

But English shareholders will not take this up unless the English Government helps in the guarantee.

Why the Government should guarantee it as a matter of course, is not easy to perceive, but this is an exceptional case. It is a highway to India better than that by the Isthmus of Suez, even were the long talked-of canal made. It is a highway guaranteed by the Sultan, and moreover a highway over which most profitable traffic must come. It makes us the protectors of the Sultan's dominions in Asia Minor as the guardians of our own rights. It opens up an enormous amount of valuable territory for cultivation, and it shortens the route to India by more than 1000 miles. It is about 4680 miles from Malta to Bombay by the Isthmus of Suez and the Red Sea, and it is little more than 3805 miles by Seleucia, the Euphrates, and the Persian Gulf to Bombay, being a difference of 875 miles; and if the mouth of the Indus, or Kurrachee, be the port of debarkation in India, the difference will be nearly 1200 miles. Supposing Kurrachee to be the sea-gate of India, it will be seen by a glance at the map that two sides of Arabia have to be coasted, and by the Euphrates only one, little more than half the distance.

The line is of peculiar value to the English Government, as it is guaranteed by the Sultan against all competition, and therefore cannot be interfered with.

English shareholders probably entertain a notion that in a despotic country, and in case of war, there would be no security for their property lying at the mercy of wild Arabs. This a fallacy. The wild Arab is essentially a merchant, a buyer and seller, as much so as a Hebrew; and he only levies black-mail upon travellers because he has no trading resources. The Arab is a man of energy and quick wit, who can work mechanically if he can get mechanical work to do, and he is the very man to deal in transit. It is quite clear that if a railway were to be made, turning the Arabs out of work and depriving them of their rights—their black-mail—it would be a cause of feud, and stealing rails, and doing mischief of all kinds; but if these same Arabs were made the police of the line, they would be at once converted from foes to friends, and would take good care that no one should injure or interfere with the line that furnished them with their salt. The Arabs, in fact, would become the workmen of the line, and grow as familiar as ourselves with rails and locomotives.

All this is theory, the capitalists would say, we must first see a line in practice. How can this be done experimentally?

There would not be much difficulty about it without any guarantee from the English Government. One of the first processes in making a railway is to lay down a temporary line, along which the materials may be conveyed. This embraces rails, sleepers, and points, and crossings, and ballast-engines, and may be estimated at from six to nine hundred pounds per mile. For a thousand pounds per mile it would be practicable to lay down a light railway and to work it by light engines. It may be remembered that at the outset the Suez route was traversed by vehicles drawn by horses, without a rail, and this gave rise ultimately to the railway. Now the distance from the shore of the Bay of Antioch to the town of Antioch is only twenty miles, and this twenty miles could be laid down with a light railway for waggons carrying half a ton per wheel, at a cost of 20,000*l.* This, at no great risk, would test the business capacity and safety of the country. If found to answer, the line could be continued to Aleppo, and thence to the head navigation of the Euphrates. This would be quite sufficient to commence the

traffic, and the railway would follow with certainty. The light rails laid down, would then serve to form branches and feeders.

Time was that Syria and Asia Minor were the abodes of opulence and civilisation, and they would be so again with facility and cheapness of transit. It is the especial aptitude of England to bring this thing to pass.

CHAPTER XIV.

RAILWAYS AS A NATIONAL DEFENCE.

MOVING LAND FORTS—RAILWAY ARTILLERY—COAST LINES—HEAVY GUNS NOT EASILY LANDED BY INVADERS—LORD OVERSTONE AND INVADERS' OCCUPATION OF LONDON—ENGLISH CHANNEL BRIDGED—BOTH WAYS—ENEMY'S CAVALRY AND RAIL ARTILLERY—INTERSECTING LINES—DOUBLE CIRCULAR RAILWAYS ROUND LONDON—COST—CLASS OF GUNS TO BE USED—RANGE AND WEIGHT—COMPARISON WITH OTHERS—RIFLING A DOUBTFUL ADVANTAGE—RIFLEMEN IN MOVING RAILWAY FORTS—GUN-BOATS AND GUN-WAGGONS.

The fact that cavalry has always been held to be an important branch of the military service, indicates that rapidity of movement is an important element in fighting battles. But horses are limited as to distance, and after long travel are unfit for charging. And, therefore, railways are most important in bringing up troops, whether cavalry or infantry. For the purpose of invading a country, railways must always be of little use, if skilfully defended, for the defenders could take up the rails and carry them off, though a

powerful army, bent on conquest, and with ample means at disposal, might of course lay down rails in advance, under the protection of artillery, just as was done at Balaklava. But for the purpose of defending a country, railways might most advantageously be used for practical fighting purposes. Supposing that a railway were made in a line parallel to the coast, with a parapet embankment, no troops could get inland without crossing it; and supposing that the opposing troops, riflemen and artillerymen, were carried on moving forts along the line, the invaders could be destroyed at will, unless we suppose vessels to lie close to the shore to support them. Supposing that by a sudden rush the invaders could get to the line and take up some of the rails, they might be between the fires of two moving railway batteries, which could retreat or advance at pleasure. In this particular, a moving fort on a railway, as compared with a stationary fort, has the same advantage that a vessel has on the water, and the invading enemy, to be on a par with the invaded, must bring batteries of railway artillery with him. And that artillery must be at least of the same weight and range as the artillery of the defenders. It would be no little labour, and

require no small amount of machinery and tackle, to get such artillery from vessels and place it on rails, and, moreover, steam locomotives would be needed to draw it. Of course it might happen that the enemy might land on a spot where no railway artillery existed, but sooner or later he must encounter some railway, which he would have to cross, and at no great distance from the coast. It would be a long process to get to London when these railways begin to thicken, though between the railroad lines there are still large gaps.

When Lord Overstone was applied to by the Government as to the financial effects likely to be produced by any enemy occupying London, he went very carefully through the question, and, quite convinced in his own mind of the amount of damage likely to result, he came to the conclusion "that it must not be," as his emphatical summing up. Now without being great arithmeticians, like Michael Cassio or Lord Overstone, there be some millions of people in this our England who have come to precisely the same conclusion by a shorter cut —the instructive process by which high-minded men and women also arrive at high resolves. The nation is at one with Lord Overstone in this matter, and the only question

is as to the greatest efficiency and economy, not penny-wise economy, but large and far-sighted wisdom.

The most economical method of using artillery is to mount it on rail platforms instead of on fixed forts or batteries, because by this process one gun becomes the equivalent of many. The obvious advantage is that an ordinary enemy can actually be pursued by the fort, instead of being permitted to move round it at a distance. The invading army would experience a difficulty of the same kind after landing as before landing—land ships, instead of water ships, carrying the heaviest projectiles at the longest ranges. And bodies of riflemen, or other accurate shooters, might be practically formed into the equivalent of cavalry, to meet any attempt to storm the line of rail, by placing them in plated waggons, shot-proof and loopholed. With long-range guns of large calibre, and so heavy as to require rails for their transit, it is obvious that an advancing foe would have to resort to similar means of attack—rails and a heavy park of artillery, steam moved. Now allowing that some of our amiable neighbours might, in spite of their deficiency in web-footedness, succeed in breaking through our first line of

defence—the Channel—and our second lines, the railways between the Channel and the capital, it would try their patience and *élan* sorely to have to carry with them so cumbrous a mass of materials for the siege—for siege it would be—of London. The burglars on a large scale have laid their plan, it is supposed, as follows: "Steam," they say, "has bridged the Channel." Perhaps: but any how it has bridged it both ways. "With a steam bridge sailors are not needed, and regiments of soldiers may supply their places. Once landed, this army of heroes can march at their ease to London, draw a cordon of unconquerable troops around it, and threaten the inhabitants with destruction by shot and shell, unless they deliver up all their wealth in the form of a contribution. The artillery for the use of the invaders is to be found all ready prepared at Woolwich Arsenal."

So now for the obstacles to the execution of this programme. Of the fixed forts at Portsmouth and other places, we will say nothing. We may assume that our dashing though burglarious enemy will avoid them. But it is difficult to imagine that all our moving forts will be absent, or that they would fail to make a considerable *battue* of their gallinaceous game,

afflicted with sea-sickness. Well, we will assume them landed, "with their gayness and gilt somewhat besmirched," and on their march inland. They reach the first intersecting line of railway, or within five miles of it, with the intention of pulling up the rails behind them, and seizing engines and carriages to carry them on; but scarcely are they within five miles, when a flying battery of heavy guns begins to pour in upon their columns shell and shot. Upon this a cloud of the improved light cavalry—the Horse Zouaves—is ordered to charge the battery and sabre the gunners. But the battery plays upon them during their whole advance, and keeps an even pace on retreating before them, at a convenient distance. They cannot charge in column, it is quite clear, or wholesale destruction would ensue; so they must keep open order, and then the sharpshooters in the battery and elsewhere would pick them off at their ease. Cavalry tactics would be clean gone at such an operation, and therefore the only chance would be to cross the line of rail, and get out of the trench as rapidly as possible. But there would be two batteries, one to the right and the other to the left, sweeping a space of eight miles between them, advancing and retreating

without the aid of horses or the necessity for unlimbering. The invaders would scarcely devote their attention to taking up rails, that bugbear so much insisted on by military men, and which rails might be relaid as rapidly as taken up. But, it may be argued, they might pass over a line of tunnel. Not much in this, for the longest tunnel is but two miles, and the surface would be swept by artillery, and a battery could be placed there on the surface. But we will suppose the invading army to have passed this Scylla and Charybdis of moving forts over a distance of eight miles, and this once closed behind them, they would then have at least two more lines to cross under the same conditions before they could get within a twenty miles' radius of London if they came by the south coast, and they would scarcely better themselves by coming by way of Essex.

They might, within five miles of this, have to encounter a circular railway, a line much needed for connecting the radial lines, and forming a parallel around London as a centre. A fifteen miles' radius would take in, or approach, Gravesend, Tilbury, Epping, St. Alban's, Uxbridge, Windsor, Epsom, and Reigate. But how about the gradients and

curves, the great elements of general cost? Simply that the rail may follow the general surface line without difficulty when the slopes are not more than one in forty, up which engines with small wheels, or, if needful, with pinioned wheels, can take the batteries at speeds of from fifteen to twenty miles per hour. Along the course of the line the structure must be simply that of an intervallic trench for the two lines of rails, with the earth dug out, thrown up on an external embankment, and with here and there a summit level communicating by a siding. An inner circle would be about an eight miles' radius from the Post-office, and would take in, or approach, Harrow, Barnet, Romford, Woolwich, Sydenham, Croydon, Wimbledon, and Staines. The outer circle would be about ninety miles in length, the inner fifty miles, and they would be connected by all the radiating lines from London, which they would intersect, passing under or over them, or communicating with them.

But 140 miles of double line of railway will cost a considerable sum of money. No doubt! The permanent way, of good quality, with various appliances, about 3000*l.* per mile, or 700,000*l.* for 140 miles of double way. But

there would be no parliamentary expenses in vexatious opposition, or buying off, and advantage could be taken of all uneven roads, and highways, and turnpike-roads, or occupation-roads lying in the track, inserting the rails at the level of the Maccadam, and leaving the defensive embankments to be made in such localities where required for use. In this mode the cost of land need not be excessive, and, at the same time, provision could be made for practice-grounds for rifle and other shooting, and also for public walks. Taking advantage of existing roads, it is probable that these two circular lines of railway could be made very cheaply, and assuredly they would be very useful lines of communication for every-day appliance, and would greatly enhance the value of the land between them and around them. And the approaches to them already exist both by road and rail. They are lines that are wanted independently of military purposes, and would greatly facilitate the cultivation and transport of fresh vegetables grown along the borders to the London markets—a very desirable thing for the inhabitants, who never obtain them but in a very minimum rate to their consuming power.

With gun-carriages purposely made to run

on rails, horses would be dispensed with, and the speed attained would set at defiance all competition on the part of an attacking foe, depending on horse transit without rails. The attack on London would be a question of regular siege, with the first parallels to be opened at five miles' distance from the outside circular line, and with the necessity for a steam railway thoroughly defended to bring up heavy artillery from the sea-side capable of as long range as the guns guarding London. And the soldiers manning the circular lines of railway would be the volunteers, whose playground they would become, and who would know every inch of their defences. The machinists would be the general railway operatives and engineers, ready to keep the whole in repair in case of damage. And this brings us to the question of the artillery.

The first consideration in every gun to produce the maximum effect is—dead weight, so greatly in excess of the projectile as to remain absolutely immovable, and free from all recoil on the explosion of the charge.

Secondly. Such a length of bore in proportion to diameter, as, while ensuring truth in the flight of the projectile, will efficiently consume the powder and expend its whole force on the projectile.

Thirdly. A simple and cheap system of breech-loading, not involving accurate workmanship, and effectually preventing the escape of gas at the breech.

Fourthly. A simple method of preventing windage round the projectile without undue friction.

Fifthly. Such a construction of projectile that it will preserve true flight from a true cylindrical bore without needing rifling to spin it through the air.

Sixthly. Such a construction of gun that it cannot be burst by any amount of powder or shot that can be placed in it.

Seventhly. Such a quality of metal that it will not wear by the transit of the shot or open into internal chinks by the action of the powder.

With regard to inertia by dead weight, both Armstrong and Whitworth claim credit for lightness, and the result is that these guns must kick and recoil unless the carriage be made very heavy.

In length of bore they have made considerable improvements from modern practices by reverting to the practice of former times. American rifles, Dutch river-guns from the Cape of Good Hope, swan-guns, and duck-guns, are all examples of long bore, which

would not be used but that they have been found a matter of necessity for long range. "Queen Elizabeth's pocket-pistol" at Dover, and the Turkish guns in St. James's Park and at Woolwich Arsenal, are also samples of long bores.

An ordinary 8-inch bore service-gun weighing 95 cwt., and carrying a 68-lb. shot, is about 12 diameters in length.

An Armstrong 3-inch bore is about 25 diameters in length.

A Whitworth 3-inch bore is about 35 diameters in length.

In a Swiss rifle, the weight of the shot compared with the gun is as 1 to 550; 8-inch service-gun, 1 to 160; 3-inch Armstrong, 1 to 75.

The long range of the Armstrong is due to three conditions: a reduced diameter of shot as compared with weight, absence of windage round the shot, thus economising the power of the powder instead of wasting it, and, lastly, an elongated shot. None of these conditions are found in the service-gun.

The defects of the Armstrong are two: want of weight and want of simplicity. There are three different diameters in the bore of the gun, and a multiplicity of rifle grooves; more-

over, the ultimate force of the powder is sustained by screw threads in the breech, very liable to get out of order by dirt, and to strain by the force of the explosion. This appears to be found out, and the screw will have to be abandoned—at least, in large guns. The lead-covered shot forced through a rifled stricture in the barrel by the explosive force of the powder with a violent blow is a mechanical error. The force should be accumulative, elastically, and not sudden.

Rifling in guns is simply a contrivance to correct the errors of imperfectly-made shot—spinning the shot to give centripetal motion, with a considerable waste of power, and with the result of weakening the gun.

Other things being equal, they whose guns have the longest range ought to be the victors. Now weight is a large element in range and accuracy, but great weights are impracticable for transit or for use as moving batteries without rails to run on; and for this reason invaded islanders have, by the use of heavy guns, an enormous advantage over the invaders, who must come by sea, even if they have the command of the sea, inasmuch as without rails the invaders cannot transport their guns, and they cannot lay down rails

while exposed to the fire of heavy guns with a five miles' range, moving at the rate of twenty miles per hour. The Armstrong guns are toys compared with the weight of metal really required. Kicking guns would overset a railway truck when fired. Heavy guns would prevent recoil.

It would be desirable to begin with a gun of 6 inch diameter of bore, 24 feet in length, and about 15 tons weight, carrying a shot of 112 lbs., a truly bored cylinder, with an accurate shot of great penetrating power, and fitting the gun elastically, as a piston fits, or ought to fit, a steam cylinder. Such a gun ought to be breech-loading for several reasons, one especially—that it requires something like a ship's spar in length and strength to charge a muzzle-loader of that size; and when muzzle-loading is used, it involves the moving of the gun, and the exposure of the gunners to the enemies' shot. Breech-loading may, therefore, be considered indispensable. Thus the length would be 1 to 48, and the weight of shot to gun 1 to 300.

There is no difficulty in breech-loading nor any necessity for complexity. The gun should be a true cylinder of nearly parallel thickness throughout except at the breech, the thickness of the barrel being at least equal to the

diameter, for with equal thickness there will be no tendency in the muzzle to throw up in the act of firing, which is the case with light muzzles. The trunnions should be changed into a circular ball capable of giving both vertical and horizontal motions. The breech should be enlarged to a sufficient size to permit of a transverse bore right through it horizontally, slightly larger than the shot bore, and either taper or cylindrical, in which a breech-pin should be made to work by a ratchet, and to give strength this breech-pin should be of elongated instead of circular section.

Much pains have been bestowed in devising mechanical arrangements to make perfectly gas-tight joints. This is mere waste of skill and money. It is a disadvantage, inasmuch as the heated metal swells and prevents easy movement to reload. There is no accurate fit needed, save between the back of the breech-slot and the breech-pin, where the pressure takes place. The leakage of gas through a comparatively open joint may be perfectly prevented by the simplest of all arrangements. It is only necessary to apply a wad of soft or elastic material behind the powder, and this will stop leakage by forcing the material in and along the joint, just as the same process

stops windage between the powder and shot, or as the leather packing in a hydrostatic press resists the leakage of the water under the enormous pressure to which it is subjected. The cartridges of breech-loading fowling-pieces are arranged in this manner, and what is good for the small gun is good for the large. How to prevent a gun from wearing in the bore or chamber is a more difficult matter, but the very fact of wear is a reason why the guns should be provided more cheaply; and efficient breech-loaders can certainly be produced at far less than half the cost of the Armstrong gun.

The merit of showing practically that rifle guns could be made on a much larger scale for long ranges than had been previously thought practicable is due to Sir William Armstrong, though long ago proposed, and the ideas printed by Robins. But it is a still more desirable thing, if practicable, to get rid of the rifling, and especially to cheapen the shot. We ought not to stop short in attaining guns that will make the attack of London an absolute impossibility as demonstrable as a move at chess or a problem in Euclid. From Woolwich Arsenal might then be poured out, at an hour's notice, batteries of

guns more rapid than the evolutions of cavalry; yet we have never once tried the experiment of making a railway gun-carriage. Artillery has never yet been produced that can be used while in motion—to shoot flying like an Arab horseman; yet this is the one which, of all others, is adapted to destroy an invading foe unresistingly. We have many stories of storming batteries, but they have all been fixtures. How to storm a battery capable of advance and retreat faster than any horse can gallop, while vomiting forth an incessant shower of shot, and this with a very limited number of men and without horses, is a problem that could only be solved by hauling up a similar battery to the attack, and that would be an impossibility unless the defences were conducted by fools or knaves, or military stores were deficient. And, moreover, it is a system that could never be turned to the disadvantage of freemen. No Government could use, for the purposes of oppression, open lines of defence, accessible at all times to the public. But fearful would be the position of invaders who, having by accident penetrated through the first line of circular railway, found themselves under the fire of moving batteries from four points of the compass.

It might cost three millions of pounds sterling to execute this work; but, when done, it would be a work that would pay interest by its use for peaceful purposes, while annoying the enemy who might wish to put aside its uses for peace.

These same railways would enable the volunteers to use really efficient long range guns. The Enfield rifle as at present constructed is supposed to be an efficient gun and an efficient two-handed sword at the same time. The result is, that it is imperfect both ways. A blow struck with it as a sword would bend the barrel, and destroy its utility as a gun. It has been stated that better shooting can be made with the Enfield rifle from the shoulder than from a fixed rest. This indicates that there is great vibration in the barrel by the action of the powder, which is partly compensated by the elastic muscles of the shooter. The sword bayonet is a mistake, and if the rifle must be something besides a gun, it is better to make it a thrusting pike than a cutting sword, whether regarding its efficiency as a weapon of offence or defence, or as a means of preventing damage to the weapon itself when in use. The bore is too large or the barrel too thin for permanent utility, and

if made heavy enough for efficient use as a gun, it would be too heavy as a pike. The sword by the rifleman's side altered to more of the Roman or Greek forms, would be a useful weapon in close combat, as a bowie or Spanish knife, but is utterly misapplied at the end of the gun. The best quality about the Enfield is the accuracy of its structure resulting from the machinery that produces it; but it is a pity that such an economical mode of construction should be wasted on an inefficient design. But whether rifling be necessary or not is a problem yet to be solved. But with mounted sharpshooters — men mounted on railway trucks with boiler-plate shelter, much heavier and more efficient guns could be used— breech-loading revolvers, with the not trifling advantage of being able to move out of their own smoke when needed. An experiment of this kind would at once settle the question of the advisability of railways for the purpose of defensive warfare. A sharpshooter not having his own weight to move about would have a large surplus of muscular power to use in actual shooting. Our cotton millowners find that it pays exceedingly well to carry their men up-stairs by steam-power instead of letting them walk up. How much more im-

portant would it be in actual warfare, in the actual shooting process, to economise the muscles of the soldier. It is getting to be a fashion to take it for granted that battles are, as heretofore, to be decided by the bayonet. If so, we had better throw away the gun altogether, and convert our men into spearmen, as of old, with supplementary sharpshooters analogous to the archers. A spear could be wielded at least four to five feet longer than the musket and bayonet, and, of course, other things being equal, the spearmen ought to destroy the bayonet men. And supposing the line broken, the supplement of the Roman sword or Spanish knife would be the co-efficient at close quarters. But the contempt for projectile weapons is an ignorant mistake, arising from their still inefficient application —their hitherto imperfect mobility. Given an appreciably longer range of weapons, and a double rate of speed, with no limit of space, five men should be able to destroy five hundred advancing to attack them, without any damage to themselves, if the attackers dared show themselves within range.

A soldier is a hunter, with, unfortunately, his fellow men for his game. An American hunter never dreams of applying a bayonet to

his rifle muzzle. If a bear charges him he takes to his Roman sword or bowie knife, and stabs the beast. But he never means to come into personal contact if he can avoid it. And as to riflemen, they are intended to keep very open order out of the smoke. If they are to stand shoulder to shoulder enveloped in smoke, "Brown Bess," loaded with a proper shot instead of an irregular sphere of lead, would be quite as efficient as the Enfield. But riflemen in close order, mounted on rapidly-moving machines behind shot-proof screens, and capable of moving out of the smoke, would prove a new instrument of defensive warfare, and a very cheap instrument too; for one man would be the equivalent of fifty in his mobility, and, therefore, he could only be vanquished by a similar instrument, or by an enormous disproportion of men surrounding and approaching with weapons of longer range. It is a question of range and speed usefully applied, to defend our island efficiently and economically, and any invader to overcome such defence would have to fight his way with siege guns of as heavy metal and range, and with railways to bear them over every inch of his projected conquest.

We want the pattern guns mounted on pat-

tern waggons, with a short pattern line of railway. It might be made at once to connect the forts that are proposed to be made. It might also open the eyes of our rulers to the praticability of a system very largely dispensing with fixed batteries. Not necessarily must the circular lines be completed at once, but it is desirable to pluck the tree of knowledge, which is not forbidden, that we may be the foremost in the act of defending this stronghold of humanity—this our England, the abiding place of freedom and light of the universe, without which the evil powers would long ere this have plunged the world in darkness. War will become the plaything of Englishmen when it becomes a railway operation. Woe betide those who may cause the play to become earnest.

The war in America has demonstrated beyond doubt that victory belongs to heavy and accurate artillery capable of rapid movement. Forts and armies have fallen down before the fire of gun-boats. Had the Confederates possessed gun-waggons on rails, they would have had the same advantages on land that the Federals have had on water. There is less difficulty in clothing a railway waggon in plate-armour than a gun-boat on water, and

the nation that wilfully ignores this modern element in war will have to deplore the oversight when occasion shall arise for its use, and perchance too late. Even as the railway has superseded the canal, so will the railway artillery, moved by steam, supersede all that has hitherto been moved by horse power.

The heroic William Peel, both in the Crimea and in India, carried his great ship guns ashore, and marched at the head of his sailors, who drew them to the siege of strongholds. Greater guns than his, with the sailors riding on them instead of drawing them, on iron instead of earthen roads, must be the rule of the future. What he improvised was sufficient for the enemy of the past. What we plan beforehand must encounter and vanquish the enemy of the future.

In the construction of guns for railways it is important to develop the essential principles of structure both of guns and projectiles. For this reason the writer reprints as an appendix an article on the subject which has already appeared in a periodical.

CHAPTER XV.

TRANSIT OF MATERIALS.

MANUFACTURES INDIGENOUS AND EXOTIC—CONDITIONS OF LABOUR IN ENGLAND—CLIMATE A STIMULUS—CAPITAL OR LABOUR—WHITE AND BLACK LABOUR IN NORTH AND SOUTH AMERICA—IRON MANUFACTURE INDIGENOUS—STRUCTURE OF SHIPS—COTTON TRADE EXOTIC—SPINNING AND WEAVING MACHINERY—YARN FAMINES—ENGLISH MACHINERY—CONTINENTAL MILLS—SLAVE TRADE—AMERICAN BREAK UP—COTTON TRADE IN LANCASHIRE IS CHANGING, AS DID HAND-LOOMS TO POWER-LOOMS—COTTON TRADE WILL FOLLOW THE GROWTH OF INDIAN COTTON, AND GO TO INDIA—ARTIFICIAL CLIMATE AND ARTIFICIAL WORKPEOPLE NEEDED IN ENGLAND—CAN AFRICANS BE BROUGHT TO ENGLAND TO WORK IN COTTON MILLS—CHANGE TO IRON AND OTHER TRADES.

In all countries trades and manufactures arise almost spontaneously from the productions of soil, climate, and locality, and, other things being equal, indigenous manufactures must maintain a superiority over exotic manufactures in the competition markets of the world. Circumstances may exist to counteract this natural condition, as, for example,

the existence or absence of roads, and the means of transit; the absence or existence of population, of fuel, or other essentials. And when various classes of materials are used, the locality will be determined by the greater or less facility of transit, and the smallest cost in transit, as well as the conditions most favourable to the health of the workpeople.

In England we have a condition of atmosphere, free for the most part, from the great extremes of heat and cold, moisture and dryness; which enables working men to live the longest lives, and perform the greatest number of days' work during their lives, of almost any known nation, provided they be not employed at deteriorating labour. And, like a hive of bees, England throws forth continual swarms of these valuable labourers, grown up to manhood, and taught trades at a cost of some two hundred pounds per head of capital sunk. This living capital has gone largely to the United States, and has essentially aided in their prosperity—*i.e.* in the Northern States—for they have been provided with skilled white labourers gratis; while in the Southern States unskilled black labourers have been purchased at two hundred pounds per head.

But the capital of England in labourers,

though apparently thus sunk, was not wholly unproductive. It produced indirectly food and other things, which came back to us in the process of trade. The United States continued to be our colony so far. If taxes are found to press too heavily there, the channels of emigration will take a new direction.

The ocean road, that cheap and broad means of transit without the cost of rails or points, crossings, or turn-tables, and only needing "moving stock," facilitates the "swarming" of the working bees, otherwise too many for the hive. But ere the swarming takes place, no means are left unturned to provide work at home. And so it comes about that we have, in addition to our native and indigenous manufactures, imported sundry exotics.

Our great indigenous business after the growth of food, is our iron manufacture in all its branches. In all the world there does not yet appear to exist a region that can compete with us. We have the coal, and ironstone, and lime lying contiguously to each other. We have an abundance of strong men to work them, and we have a climate in which not to work is a penalty so strong, that rich men ride, and row, and play at cricket, and hunt,

and shoot, and do various kinds of mischief, rather than be idle.

It is then no marvel that we excel the whole world in the production and uses of iron, and in the uses of all other metals. When the French Emperor gave a stimulus to the production of iron ships for war, he made a strategical mistake in competing for ocean superiority in iron ships with a nation to whom iron is as indigenous as the ocean is native. We are a webfooted race. We began with pine in the far north, till we changed to heart of oak, and then to iron, and now that the iron is to be clad in massive iron armour, more than ever indigenous is our vocation in its construction. And the workshops, wherever it is made, are all a reproductive outlay available for times of peace, till needed temporarily for war purposes, and then again reverting to peace usage. A nation must not quarrel with us, that depends on us for supplies; and if France makes her own armour-plates, her workshops must cost more than ours, and will not to the same extent as ours represent reproductive capital.

Ships, and henceforth forts, and guns, and shot, and engines, roads, machines, and buildings, and bridges, must all be constructed of

iron, and evermore, till the coal is burned out and our ironstone shall be consumed, the production must go on increasing for our own uses and those of our customers, unless a more favourable conjuncture of circumstances shall arise in some other portion of our globe.

Our coal and iron, and machine-making faculties, have created another huge trade, which is not indigenous, but exotic. Well has it served us in finding the wealth to defend our freedom against a despot with Europe's nations banded round him, and finally to conquer him, and set the nations free from foreign conquest. How this trade came to us, and the results it has led to, let us inquire.

Of wool and flax, and skin and leather, and some infinitely small quantity of silk, were our garments made ere the discovery of the sea-road to India by Albuquerque. Then first came cotton to our knowledge as calico and muslin, and then nankeens, still telling their origin in their names. Webs, as of "woven wind" and of dazzling whiteness, startled our English women with their beauty, and fairy tales seemed realised in spangled fabrics. Indian fingers could do work upon a material that England knew not, and English fingers were too muscular to turn to account.

But a change came about when multitudes of twirling wires, set in motion by the rain of heaven through the agency of water-wheels, dispensed with the distaff and spinning-wheels, and the "spinning jennies" of flesh were multiplied by hundreds and thousands in metal. Still greater was the change when, for the uncertain and inconvenient power of water, was substituted the certain power of the steam-engine. The "yarn famines," which had limited the numbers of the hand-loom weavers, disappeared for ever, while the material was to be had, and hand-loom weavers grew and multiplied. No Indian hand-workers even at a penny a day could compete with their myriads of spindles. Europe and the world were saturated with yarns, for all the hand-loom weavers that could be found.

But a greater change came when the power-loom, moved by steam agency, gave over the masters, and still more the workers, of hand-looms, to misery—to fight a long and trying hopeless battle against the world's progress—still keeping to England the control of the world's cotton markets, while the world, taken up with war, had no time to give to the imitation of English mill-owners. That also came to change, and the European nations, with

surplus populations and low wages, took to cotton milling also. But England prohibited the export of machinery, and many were the smuggling operations that gave the Continent the first patterns. The prohibition laws were relaxed in time to prevent the early embarkation of the Continent in machine-making, and that gradually became a large and valuable trade to us.

The supply of cotton finally centred in America, fostered by the slave trade, and Lancashire became indirectly the great slave-owner of the world, long after England had freed the last of her own slaves. Political economy denounced it—did not recognise such prosperity as possessing the elements of permanence; and a change had to come about, for slavery is not an institution of civilisation. but only of barbarism, and barbarism is ever losing ground in the struggle with civilisation. The crisis came at last, and the supply of cotton is broken off by the war in America, which, end how it may, whether in reunion or separation, will never again make Lancashire a dependency or suzerainty of American Cotton States. Misery, like to that of the hand-loom weavers, has again fallen on Lancashire, and now in their distress they

turn their eyes in search of relief to that very India which, in the olden time, was deprived of her trade in cotton cloth, by the very ancestors of the men who now claim her help.

It will only be for a time. Manchester men will aid in procuring the culture of cotton in India, but Manchester men will soon discover that Indian cotton will afford a better profit in the markets of England and of the world, if the cotton be brought from India in woven webs instead of in bales.

In India may be found an almost unlimited population of men, women, and children, with delicate nervous organisation, and long thin fingers, specially adapted to the production of textile fabrics. Their wages are from 2½d. to 3d. per day.

To work cotton in England we require an artificially-heated climate in the mill, and we require a peculiarly constituted race of people analogous in their nervous organisation to Hindoos. To maintain them in health they need as wages at least 2s. a day. These people, comparatively weak and delicate, require more food and of a better quality than that needed by agricultural labourers, for their inferior health and the impure atmosphere they breathe requires double the quantity for their

digestive organs to operate upon, in order to absorb enough to keep up the system, than is required by the agriculturists, whose ample supply of oxygen enables them to absorb almost the whole quantity of food they put into their stomachs. Were the mill-worker only supplied with the same quantity as the agriculturist for his stomach to operate on, he would die of want. Were the mill-workman to get into the fields his appetite would at first become stronger, and then gradually he would need less food. This fact is clearly expounded to us in the sewage statistics of towns. The value of town sewage to land is twice to thrice that of agricultural; in other words, the nitrogenous parts go off unabsorbed. Thus, in stable-yards where oats are unbruised, fowls and pigeons may be kept unfed; where the oats are bruised, the pigeons and fowls are starved.

As regards the cotton manufacture, England has the advantage of India in the steam-engine and machinery. India has the advantage of England in labour at one-eighth of the cost. If, then, India obtains the steam-engine, for which she has coal, and the machinery, supplied from England, she will have an enormous advantage, in addition to an-

other advantage she already possesses—a more favourable climate and a saving in freight.

If England could get cheap labour—say, by importing Africans for three or four years and then returning them to help to civilise Africa—if she could do this by dint of thoroughly warmed and ventilated mills and dwellings, England might possibly compete with India; but even then it is a question whether mills would not go to Africa where cotton will grow, also, if African fingers can serve for cotton handling in threads and webs as well as in ginning. From the cotton-gin to the spindle and loom is no great step.

The probability is, that the mills already in India will be increased, and will gradually compete with Lancashire, and that London will be the great emporium of Indian bales, not of cotton bales, but of spun and woven cloths and muslins, and of every variety of cotton fabrics, and the Europeans would all be supplied by us. India is a part of England, as is Lancashire, and delicate workers being a staple of India, political economy dictates that the exotic must give place to the indigenous. It is quite in rule that India should supply us with cotton cloth, and that we should supply India with iron and machines.

Much misery must be undergone by the change in Lancashire, but it is in the order of nature that it should take place. As the hand-loom weavers gave place to the steam-loom trades, so must men at 2s. a week give place to men at 3d., unless by mere chance they rise to a balance.

But the natural men of an English climate are strong and muscular, as the natural men of India are delicate; and, save the misery to be endured in the change, and which the accumulated capital of Lancashire must be heavily taxed to alleviate, it is better that England should be peopled with muscular iron-workers than with delicate cotton-spinners and weavers. Slowly but surely will this process come about, and by the agency of long-headed Manchester men.

For the chief purpose of transporting bales of cotton-wool from Liverpool to Manchester, and bales of cotton-cloth from Manchester to Liverpool, was the Liverpool and Manchester Railway constructed. But if the cotton trade depart altogether, not therefore will the railway cease to be a utility and a profit. It will change the character of its traffic, and carry machinery and other things instead of cotton. Whether some other fabric that can be worked

by less delicate fingers, and in a more healthy atmosphere, will take the place of cotton, is yet to be seen. Probably inventors will be at work on something new.

Changes will take place, but railways and land will continue to increase in value by their mutual influence on each other, and the increase of population. The processes that have cheapened factory labour will gradually improve transit and reduce its cost to a minimum, which we are yet very far from having obtained, though quite within reach, when the attention of those who conduct it shall be really given to it, with an earnest desire to attain it, not merely as a question of cost, but of public safety also. Absolute safety can only be attained by the very processes which are essential to diminish cost, and not to increase it. Nothing can well be more costly than existing unsound empirical practise, compared with the results to be obtained from sound mechanical and commercial principles.

The process which will probably bring about improvement will be the construction of new lines giving greater safety and comfort to the passengers, at a lessened cost for transit. Is there any reason why railway carriages in Prussia should be more comfortable and con-

venient, and the fares considerably lower, than in England? Only this. That we are stereotyped, and every proposition for an alteration is met by resistance, as Government officials well know. Improvements are denounced as "new-fangled" until they have been ten years in use, though it would be just as reasonable to refuse armour-plates to our ships till they have been ten years in use. There is no more difficulty in crowding a ten years' experience of railways into two months of experiment, than there is in shooting at and crushing an armour-plate the moment it is produced. Doubtless the first maker of a driving-nail denounced the first screw-nail as "new-fangled," just as the users of railway rollers or sliders denounce wheels proper, albeit that a Government engineering authority talk himself dumb in demonstration. But there is no royal road to improvement, and we must be content with the devious path of stereotyped empiricism.

APPENDIX.

GUNS AND ARMOUR.

A short time back I expressed my conviction that shot from a smooth bore would make a breach in the Warrior's side. It has now been accomplished by a gun produced by Sir William Armstrong. It comes to the result, long foreseen by those who really thought on the matter, that it is simply a question of a gun that cannot be burst. Given a sufficient mass of powder to be used efficiently, no vessel that can float can *resist* the effect of a point-blank shot from such guns as are within the range of possibility, though the problem is not yet worked out as to what may be done to deflect or elude the shot.

What Sir William Armstrong has done, is to produce in wrought-iron a gun similar in all respects to the ordinary 68-pounder service gun, with all its defects. It is more of a "Carronade" than a "Long Tom," being about fourteen diameters in length, smooth bored, and muzzle loading. The gun originally known as the Armstrong gun, was twenty-five diameters in length, breech loading, and rifled, while that of Whitworth was thirty-five diameters in length, breech loading, and rifled. If these guns were correct in their proportions, it follows that the reduced length must be incorrect, so far as regards ranges. We should never think of mounting a fort with carronades, or of using them as chase-guns, and therefore we must regard this last gun of Sir William as simply a machine for battering iron-sided ships yard-arm and yard-arm.

But long and accurate range originally sought for by Sir William, and now treated lightly, is an important element of success, both in action at sea and for the purpose of land forts. It is quite clear that a ten-mile range, with accurate and effective striking from a land fort, would keep any bombarding squadron at a sufficient distance from Portsmouth dockyard. Long range is only a convertible term for very hard hitting at short range, which is very doubtful with the present gun of Sir William. What it has achieved is as a smooth bore, with a cast shot of 150 lbs. at 200 yards. What it will achieve when rifled, with a 300 lbs. elongated shot, remains to be proved.

There is no doubt that rifling a gun weakens it very considerably by providing a number of twisting angles, and if the rifling could be dispensed with, a great gain would be achieved in many ways. What is the object of rifling? Simply to correct the defects in flight of a badly-proportioned shot. If a spherical shot be of cast metal, the chances are that the centre of gravity does not correspond to the centre of form, in which case if the weighted side be accurately in front at the time of discharge, accurate flight may be obtained; but if the weighted side be behind, or on one side of the gun, erratic and uncertain flight will be obtained. To correct this evil, rifling was invented to spin the shot as a boy spins his top, whirling action keeping the irregular form in balance. And if we come to the elongated shot, originally resorted to for the purpose of increasing the weight without increasing the diameter and atmospheric resistance, we should find that if discharged from a smooth bore, their improperly adjusted centre of gravity would induce them to turn over in flight, with entire uncertainty where they would go to.

But if the figure of the shot were so adjusted that it would preserve an even and direct course without spinning, a great gain would be achieved. The gun would be much stronger to resist the strain of the powder, and a waste of force in friction would be avoided. For this reason the writer has from the first endeavoured to impress on the public mind the probability that rifling is a fallacy, seeking to correct the evils of a bad shot by the construction of a faulty gun.

But there is more than this. The great comparative range of rifled cannon has been obtained not by the rifling process, but in spite of it. Expending power in spinning a shot in no way tends to increase its velocity, as proved by the experiments on targets—but the contrary. The reason for the greater range is found in the diminished area of the shot giving a diminished atmospheric resistance. But, other things being equal, the velocity is determined by the area of powder surface, and while diminishing the resisting area of the shot, the small bores resorted to have diminished the propelling power.

For this reason the writer was the first to enunciate the true principle of procedure, viz.:—*To use an elongated missile of reduced diameter, capable of maintaining a straight course through the atmosphere, and to propel it by a gun of increased diameter, thus, reducing the area of atmospheric resistance, and increasing the area of propelling power, with any desirable weight of missile; the gun being in all cases of sufficient length to consume without wasting the largest quantity of powder that it will burn without bursting.*

Such a gun would be equally adapted to throw a round shot at close quarters, or an elongated bolt at long range.

In the discharge of elongated shot it is essential to accuracy that the bore should be sufficiently long to expend the powder before the shot escapes, and that the axis of the shot should be maintained centrally to the axis of the bore. With a shot of the same diameter as the bore this takes place; but with a shot of reduced diameter, a *carrier* must be resorted to which will, at the same time, receive the impact of the powder, and transmit it to the shot while closing the windage.

In constructing shot we have to consider, first, accurate flight; secondly, range; thirdly, power of penetration. In range and penetration, spinning a shot is disadvantageous, for force is expended partially laterally, instead of entirely forwardly; and this it is which gives great advantage to the direct smooth bore, and a shot with a rounded end, or a blunt cone, will have little penetration, save by great power. If we want to disable a mischievous bull, we put round balls on the

ends of his horns, and so we do with small swords when we wish to prevent penetration. A rifle-ball from an Enfield would strike through two or three men, and stop in a fourth, inflicting ghastly, ragged wounds. A sharp-pointed shot would probably go through twenty, inflicting disabling wounds or death wounds, without cruel wounds. Again, a sharp-pointed shot against stone walls would act like a crow-bar, penetrating deeply, and dislodging stones, instead of merely battering the surface, and if provided with bursting charges they would be the most fatal of all to masonry. There is an apparent objection to the use of internal carriers for elongated shot, as they must be left behind at the muzzle, and may damage troops, but for ship-guns and trenching-guns there is no difficulty, and for field-guns the carrier may be formed on the shot itself, and go with it. In any case the fit of the shot in the gun should be elastic, without involving useless friction.

There are four modes of constructing great guns—first, the method of casting entire and forging out; secondly, the method of putting on coils round a built gun, and adopted by Sir William Armstrong, with the addition of an inner tube; thirdly, the method of Captain Blakeley, of shrinking rings over rings on an inner tube, with increasing tension; and, fourthly, the method of Mr. Longridge, of winding an endless skein of wire over a tube, also with increasing tension. The power of resistance to make an unburstable gun will probably be found in the wire, as well as the greatest rapidity of production. The process of welding must ever be an uncertain one when small pieces are welded into a large mass; and it seems that Sir William Armstrong has taken some twelve months to produce his first large gun.

But the new gun must be a breech-loader. And if a large gun is to be made sufficiently long for range, it will be difficult to make it a muzzle-loader. It would take a small mast of timber for a ramrod. It is probable that guns of fifty tons weight will be needed, and that they will be mounted in towers or cupolas. If so, they will be made to form a portion of the iron rampart, with a hinge to move vertically—if on a revolv-

ing cupola, or if on a ship's side, with a ball and socket joint, In this mode the port-hole might be completely stopped, and the sound of the report excluded from the interior, the elevation or depression of the gun being accomplished by a hydraulic ram. Weight in the gun to prevent all recoil, and so to expend all the force of the powder in the shot will be a matter of necessity, and in that case there would be no shaking of the vessel.

There is nothing extraordinary in the last gun or result of Sir William Armstrong, beyond the fact of the length of time it has taken to make it. The Mersey gun did just as much, and Mr. Longridge long ago stated that he would pledge his reputation to produce a wire-bound gun rapidly, which should drive a shot in at one side of the Warrior and out at the other. Sir William has not yet achieved this.

The qualities required in the gun are:—First, rapidity of production; secondly, impossibility of bursting; thirdly, greatest possible size of bore; fourthly, great length, to consume a large amount of powder, and give extreme range and force of penetration.

So far as we have gone the victory of ships' guns over defences is established. The guns have prevailed against the present armour; but all has not yet been done that may be done to make the armour effectual. If we want to punch metal, we use a solid block, and nothing can be imagined more solid than the Warrior's sides. The rails that covered the Merrimac were not solid, but yielding. Hudibras tells us of

> Feather-bed 'twixt castle wall
> And heavy brunt of cannon-ball,

and herein lies a truth. If the four-and-a-half inch plates were reduced to three inches, and placed at an angle, a three-eight thickness of tempered steel might be applied in the form of springs between the armour and the ship's side, permitting a recoil of from four to six inches. The probability is that such an arrangement would elude the shot. The plates are not to be bolted, but arranged in ribs, forming hinges, to allow free movement when the springs yield to shock.

The object of the writer of this paper is to draw the attention of the public, both rulers and ruled, to the fact that the resources of art are not yet exhausted either in guns or armour, and to indicate a course of yet untried experiment which philosophical theory points as based on known principles. It may be asked, why not lay the plans before the authorities? The answer is, that the authorities are probably overwhelmed with applications and propositions; and the writer does not wish to enter the arena of what doubtless is anathematised by them as "boredom." Public agitation is the most legitimate method of sifting novelties that are beyond private means of experimenting; and in these days of publicity, locking up a secret known to all the world in a box at the Patent Office is a farcical absurdity. No man of good feeling would willingly carry plans of attack and defence across the Channel—the *English* Channel; but neither, on the other hand, would he desire to imitate the ostrich, hiding his head, with his body in view.

THE END.

C. WHITING, BEAUFORT HOUSE, STRAND.